STATE of the Environment QUEENSLAND 2003













Queensland Government



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Project management: Lynne Turner, with assistance from Lachlan Hurse, Karen Macintosh and Dr Laurence Knight. Preparatory work by Peter Bek and Derek Benjamin is also acknowledged. Special thanks to Dr Joe Baker, Department of Primary Industries, for his advice and support throughout the project.

Strategic direction and advice through the Interdepartmental Committee: Shannon Burns, Rosey Crisp and Tracey Dawson, Department of Aboriginal and Torres Strait Islander Policy; Gavin McCullagh and Fiona McKersie, Department of Emergency Services; Jill Lang and Rick Lennon, Department of Families; John Abbott, Dr Ted Campbell, Patricia McKay and Johan Pretorius, Department of Local Government and Planning; Dr Joe Baker, Peter Johnston and John Pollock, Department of Primary Industries; Ron Apelt and Dale Gilbert, Department of Public Works; Graeme Harding and Al Wagner, Education Queensland; Kathryn Adams, Dr John Cole, Olwyn Crimp, Dr Brian Head, Dr Ian McPhail, Chris Pattearson, James Purtill and Bob Speirs, Environmental Protection Agency; David Bobberman, Bob McPherson, Robin Stone and David Wright, Department of Main Roads; Ann Bainbridge-Robb, Brian Bycroft, Allan Dale, Terry Hogan, Rowena McIntosh, Bernie Powell and Chris Robson, Department of Natural Resources and Mines; Lyn Allen, Amanda Hill and Liz Young, Department of the Premier and Cabinet; Dr Philip Baker, Sophie Dwyer, Ian Marshall and Shannon Rutherford, Queensland Health; Tony Ramsden, Queensland Rail; Rick Andrew, Phil Henry and Geoff Mercer, Department of State Development; John Chapman and Greg Fill, Queensland Transport; David Shearer and Graham White, Queensland Treasury; Tom Hassed and Nicholas Lindsay, Office of Energy; David Morgans, Mark Olsen and Michael Sommers, Tourism Queensland

Editing: Julie Freeman

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Indexing: Max McMaster

Design and layout: Karen Stobbs and Kylie Wiemers-Wingett, Environmental Protection Agency

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Naturally Queensland Information Centre

160 Ann Street Brisbane
PO Box 155
BRISBANE ALBERT STREET QLD 4002
AUSTRALIA

Tel.: 07 3227 8197
Fax: 07 3227 8749
Email: NQIC@epa.qld.gov.au
Website: www.epa.qld.gov.au

Foreword

I am delighted to present Queensland's second state of the environment report. It is a comprehensive review of the condition of Queensland's environment.

We have heard for many years that the environment is our single greatest asset. It provides the natural resources upon which a large proportion of Queensland's economy is based: our mineral, agricultural, fisheries, forest and energy resources, our biodiversity and the natural and cultural resources that make Queensland such a great place to live in and visit. The environment also sustains us by providing the fundamental ecosystem services upon which life depends. The quantity and quality of our air, land, water, coastal zone, biodiversity and natural and cultural heritage are being placed under increasing pressure.

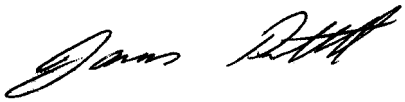
Ecologically sustainable development is no longer just a desirable goal of society, but a necessary one. Only by ensuring that our actions result in environmental impacts that are acceptable in the long term can we ensure that our children inherit the same opportunities to prosper as we enjoy today, or even greater ones. A growing body of evidence is emerging that such an approach leads to a genuine long-term competitive advantage and a profitable economy, and sustains our way of life both today and in the future.

The state of the environment report is produced every four years. Such a timeframe allows us some opportunity to assess the effectiveness of our endeavours to ensure that we are adequately protecting our most significant asset. Even so, many natural and cultural systems change incrementally over far greater timeframes, and assessing our impacts upon them can pose a great challenge. We remain committed to continually assessing and improving the science underpinning our assessment of the state of Queensland's environment.

Has the environment in Queensland improved since 1999, when the Queensland Government published its inaugural state of the environment report? Such a question remains complex and difficult to answer, given the ever-growing demands placed upon our natural and cultural systems. Overall, while demonstrable improvements have been made in some areas (such as air quality), our commitment to improvement must remain, to arrest and reverse the decline in condition occurring across a range of Queensland's natural systems. Our ever-increasing population, need for economic growth and changing climatic conditions will continue to drive the need to maintain economic development, employment opportunities and our way of life without compromising environmental quality.

State of the Environment Queensland 2003 is the result of the efforts of a large number of individuals and organisations, both private and public, who provided information and time for its development. The Environmental Protection Agency is indebted to these people, and remains committed to ensuring that every endeavour is made to continually improve Queensland's environment.

I commend this report to you and trust that it will contribute to maintaining and improving our unique environment and quality of life.



James Purtill
Director-General
Environmental Protection Agency

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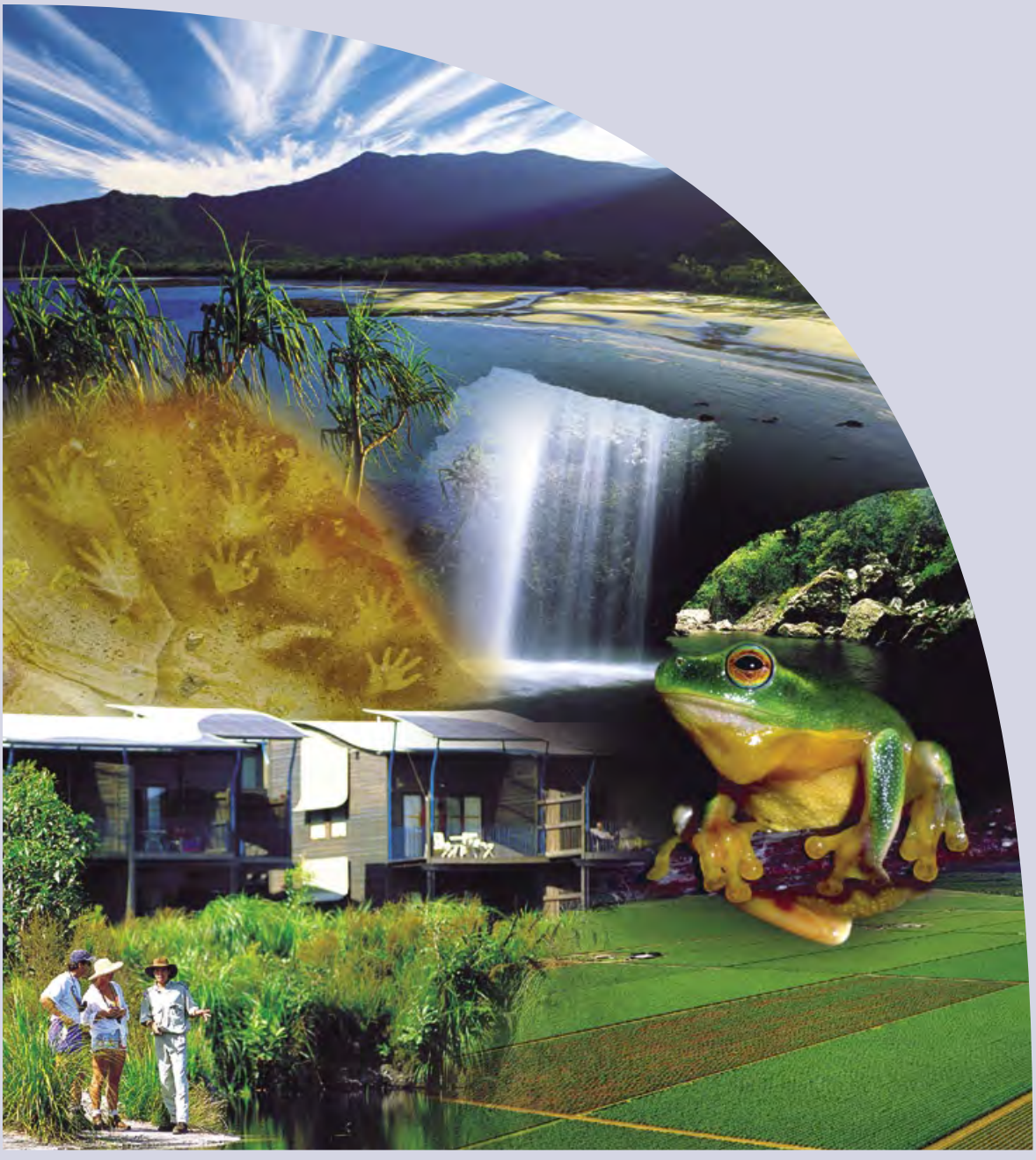
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Atmosphere

Queensland's air quality is generally good, with relatively few exceedences of air quality standards recorded in the period 1999–2002. Regionally, the significant issues are sulfur dioxide concentrations in Mount Isa, particulates and photochemical smog in south-east Queensland, and visibility in Mackay. While there were steady increases in greenhouse gas emissions in the transport and stationary energy sectors between 1990 and 1999, livestock emissions were relatively steady, and land clearing emissions fluctuated considerably. In particular:

- Queensland produced the equivalent of 135.2 million tonnes of carbon dioxide in 1999. The main contributors to these emissions were stationary energy (mostly electricity production—37.3%), land clearing and forestry (24.7%), agriculture (18.5%) and transport (11.4%).
- Average carbon dioxide concentrations at Cape Ferguson near Townsville increased from approximately 355 ppm in 1992 to about 370 ppm in 2002. Average methane concentrations increased from around 1670 ppb in 1992 to about 1710 ppb in 2002.
- Stratospheric ozone losses over Queensland are estimated to be 1% a year.
- Photochemical smog concentrations exceeded Air NEPM standards in south-east Queensland on an average of two days per year between 1999 and 2002.
- Motor vehicle emissions were a major source of smog precursors in south-east Queensland: 62.2% of oxides of nitrogen (NO_x) and 22.0% of volatile organic compounds (VOCs). Other main sources included biogenic emissions from vegetation (7.8% of NO_x and 61.2% of VOCs), and industry (15.9% of NO_x and 4.0% of VOCs).
- Particulate levels in south-east Queensland, Gladstone, Mackay and Townsville (as measured by the 95th percentile 24-hour PM_{10} concentration) are normally in the range 25–40 µg/m³, below the Air NEPM standard of 50 µg/m³. Exceedences are a result of bushfires, cane burning and dust storms.
- Burning vegetation released 15 640 tonnes of particulate matter (66% of total emissions) in south-east Queensland in 2000, while industry released 4900 tonnes (21%) and motor vehicles released 2250 tonnes (9%). A severe bushfire season in 2000 was the main source of vegetation burning emissions of particulate matter for the year highlighting the way in which air pollution levels can vary according to circumstances.
- Bushfires, cane burning and dust storms were the main causes of poor visibility between 1999 and 2002.
- Visibility fell below the target of 20 km on a number of days during the period 1999–2002 in south-east Queensland and the Gladstone and Mackay regions. How often poor visibility occured varied each year due to the occurences of bushfires, cane burning (Mackay only) and dust storms.
- Motor vehicles released 2277 tonnes of benzene (76% of total emissions), 3583 tonnes of toluene (40%) and 1531 tonnes of xylenes (35%) in south-east Queensland in 2000.
- Maximum 24-hour concentrations of benzene were in the range 0.6–1.2 ppb at monitoring sites in Brisbane and Gladstone in the period 2000–02. Maximum toluene concentrations were in the range 4.9–21.5 ppb at Brisbane monitoring sites and 2.5–47.9 ppb at the Gladstone site. Maximum *p*-xylene levels were in the range 1.8–3.0 ppb at Brisbane monitoring sites.
- Motor vehicles released 417 317 tonnes of carbon monoxide (88.3% of total emissions) in south-east Queensland in 2000. No exceedences of the Air NEPM standard for CO concentrations were recorded in 1999–2002.
- Motor vehicles released 60 579 tonnes of nitrogen oxides (70.9% of anthropogenic emissions) in south-east Queensland in 2000. No exceedences of the Air NEPM standard for NO_2 concentrations were recorded in 1999–2002.
- Industrial sources released 18 328 tonnes of sulfur dioxide (75.0% of total emissions) in south-east Queensland in 2000. No exceedences of the Air NEPM standard for SO_2 concentrations were recorded in south-east Queensland, Gladstone or Townsville in the period 1999–2002. The Air NEPM was exceeded on an average of 35 days a year in Mount Isa in the same period.



Atmosphere
(Photo: Tourism Queensland)

Land

Land condition varies considerably across Queensland, and is influenced by geological, climatic, land use and biotic factors. Key issues include the clearance of deep-rooted vegetation, salinity, acidification, soil erosion, soil compaction and fertility decline, and the impacts of invasive species.
In particular:

- In 2002, Queensland had 1 137 600 km² of leasehold land (a 1.4% fall since 1997); 340 700 km² of freehold land (an 18.8% increase); 108 560 km² of freeholding leases (a 33.5% fall); 71 130 km² in the protected area estate (a 2.7% increase); 42 390 km² of state forests and timber reserves (a 0.4% fall); and 26 620 km² of other state land (a 127.3% increase).
- The area of land under crop ranged between 26 840 km² in 1997–98 and 31 300 km² in 2000–01, in response to climate and market factors.
- Queensland has 46 million ha of forested land: 61% is leasehold land; 20% is privately owned; 8% is public forests; 7% is conservation reserves; and 4% is other public lands.
- Between 1995 and 2002, 6986 ha of good quality agricultural land in south-east Queensland was converted to other uses.
- Land clearing peaked at 757 800 ha in 1999–2000; 94.5% of the land cleared in that year was converted to pasture.
- Total livestock numbers were in the range of 11–12 million adult beef equivalents in the period 1999–2002.
- Mining and petroleum tenements cover 41.7 million hectares. Approximately 87 400 ha of land has been disturbed by mining and petroleum activities (13 190 ha since 1999), with 29 800 ha of that land rehabilitated (6750 ha since 1999).
- In 2002, 107 000 ha of land was identified as saline; another 3 100 000 ha has the potential to be saline by 2050.
- Salinity in 2050 may affect 2 600 000 ha of agricultural land, 92 000 ha of remnant vegetation, and 26 000 ha of Ramsar-listed and other important wetlands. It may also affect 1800 km of waterways, 12 000 km of roads and 15 000 km of railways.
- Watertable levels rose rapidly in a number of irrigation areas between 1990 and 2000.
- Water erosion is a widespread problem in areas with high-intensity rainfall.
- Wind erosion levels fell during the higher-rainfall period of 1998–2001, but increased with the onset of drought in 2001.
- Acidification is a significant soil management problem in many agricultural regions.
- Soil nutrient (carbon, nitrogen and phosphorus) levels are falling in most of Queensland's cropping lands.
- Since 1998, permits have been granted for the disposal of 408 500 m³ of contaminated soil to landfills.
- Pasture condition in many regions is under pressure from drought, vegetation thickening, grazing pressure and noxious weeds.
- Large areas are affected by pest plants and animals. Some pest-control activities are proving effective.



Land use (Photo: DNRM)

Inland waters

Queensland's rivers and aquifers are under pressure from increasing levels of water diversion for consumptive purposes. The main factors affecting water quality are eutrophication, chemical contamination and salinity; these are largely the result of discharges from urban and agricultural areas. Other key factors affecting river health are the condition and extent of riverine vegetation, disruption of stream flow, and invasive species. Wetland management is becoming a more important issue. In particular:

- Long periods of below-average rainfall and high levels of consumption have led to a widespread decline in groundwater levels. Groundwater in more than half the state's groundwater management units is either over-abstracted or approaching the upper limits of sustainable abstraction.
- Uncontrolled bores and excessive water extraction have caused widespread falls in pressure levels in the Great Artesian Basin. Many natural springs no longer flow.
- In July 2002, Queensland had 567 open artesian bores and 15 305 km of bore drains. Approximately 95% of the water flowing is wasted and facilitates the spread of pest plants and animals.
- Bore rehabilitation began in 1989. Between 1989 and 1999, 347 bores were rehabilitated and 2078 km of bore drains replaced with piping. Between 1999 and 2002, a further 69 bores were rehabilitated and 1747 km of bore drains replaced. These works save approximately 80 000 ML of water each year.
- Groundwater quality ranges from poor to moderate. Elevated nitrate levels and salinity are the main problems caused by human activities.
- Surface water consumption reached 2 969 000 ML in 1996–97, a 145% increase since 1983–84. Most of that water was used for irrigation (73%) and urban and industrial uses (26%).
- There were 25 875 water licences in 1998, 26 428 in 2001, and 22 478 in 2002.
- Since 1999, approval has been given for the construction of two new dams and two new weirs, and for the raising of another dam and another weir.
- The Haughton, Kolan, Macintyre, Moonie, Condamine and Warrego rivers are categorised as highly regulated, and the Condamine and Kolan rivers are also subjected to high water abstraction.
- The *Water Act 2000* introduced water resource planning, and the Queensland Government has undertaken a range of rural water use efficiency initiatives with agricultural industries.
- The main point sources of aquatic nutrients are sewage treatment plants and intensive animal industries, while eroded soil, plant litter, livestock manure and fertilisers are the main non-point sources. Most rivers have high phosphorus loads, while the Fitzroy and Burdekin also have high nitrogen loads.
- Cyanobacteria (blue-green algae) have been found in 70% of Queensland reservoirs, at least on a seasonal basis.
- Pesticide testing in the Condamine River between 1993 and 2001 found reductions in the levels of endosulfan measured (zero levels for 1999–2001). Atrazine and metolachlor were found in 72% and 65% respectively of samples tested, often at levels in excess of drinking water guidelines.
- Samples taken at a large proportion of monitoring sites in the Burnett–Mary, Fitzroy, South West, South East, Mackay–Whitsunday, Burdekin Dry Tropics and Southern Gulf regions exceeded guideline levels for salinity.
- South-east Queensland had the highest proportion of waterways with macro-invertebrate populations well below reference levels.
- Riparian vegetation along more than half of the stream lengths surveyed was in poor condition.
- There are widespread problems with riparian weeds throughout Queensland; the Fitzroy and central Burdekin river basins have the highest number and density of exotic weeds.
- Of Queensland's 71 000 km² of wetlands, 69% are seasonally or intermittently inundated, while 14% are tidal wetlands.
- The extent of wetland loss is unknown.
- The numerous barriers to the movement of freshwater fish have significant impacts on fish populations.
- Sixteen species of exotic fish have formed significant self-maintaining populations in Queensland waters. Carp, tilapia and gambusia are considered to pose the greatest risk. Most river systems (with the exception of the Lake Eyre and Gulf drainages) have been invaded by one or more exotic species.
- Commercial eel catches are declining, apparently due to overfishing and lack of recruitment.
- Six species of freshwater fish are considered critically endangered, and a further six are considered vulnerable.



Natural bridge, Springbrook National Park (Photo: Tourism Queensland)

The coastal zone

The coastal zone is the focal point for human–environment interactions in Queensland. While it contains many sensitive ecosystems, it is home to most of the state's population and the site of many intensive economic activities. Queensland's coastal waters are the ultimate sink for many stormwater, waste and nutrient discharges. Growing populations and rising levels of economic activity are placing increasing pressures on the coastal zone. In particular:

- Queensland's coastal zone is home to around 85% of the state's population.
- More than 5000 ships (moving 180 million tonnes of cargo and 130 million tonnes of petroleum products) visit Queensland ports each year.
- Approximately 16 000 000 people visit coastal regions in Queensland each year; these include 1 600 000 tourists visiting the Great Barrier Reef.
- There were an average of 75 oils spills a year in Queensland waters in 1997–2002, 99% were not significant.
- A total of 6 144 865 tonnes of extractive materials was dredged from 86 sites between July 1999 and June 2002.
- Of 29 important fish stocks in Queensland, 12 have a low risk of being fished unsustainably, 14 have a medium risk and 3 (shark, snapper and grey mackerel in the Gulf of Carpentaria) have a high risk.
- Queensland had 1088 ha of aquaculture ponded areas in 2001, including 665 ha of prawns, 182 ha of barramundi and 140 ha of crayfish.
- Nutrient discharged via wastewater accounts for approximately 40% of the total nitrogen and 60% of the total phosphorus released to coastal and estuarine waters in south-east Queensland; levels are typically below 10% elsewhere in the state.
- Diffuse runoff from cropping and grazing lands contributes more than 90% of nutrient loads in catchments north of Bundaberg.
- Water quality sampling in east coast waterways found less than 9% in the Wet Tropics in poor condition. In the Burdekin Dry Tropics, more than 35% of sites were rated as being in poor condition, as were 23% in the Mackay–Whitsunday region, 17% in the Fitzroy, 13% in the Burnett–Mary region, and 22% in south-east Queensland.
- Pesticide sampling of marine organisms found elevated levels of atrazine, diuron, dieldrin, dioxins and organochlorines in a number of coastal waterways and seas.
- Recreational water quality at both beach and river sites in south-east Queensland has generally improved, river sites increasing from 44% to 83% compliance between 1998–99 and 2000–01.
- While the majority of the state's estuaries are in good condition, almost all the estuaries in south-east Queensland are in poor to moderate condition.
- Ten of the twenty listed weeds of national significance occur in coastal areas of Queensland.
- There have been increasing reports of outbreaks of Lyngbya blooms in Deception Bay since 1990, in other parts of Moreton Bay since 1997, and in five areas along the Queensland coast at the end of 2002.
- There were significant outbreaks of crown-of-thorns starfish on the Great Barrier Reef in 1999 and 2000.
- The worst recorded coral bleaching episode was experienced in the Great Barrier Reef in 2002, when almost 60% of 641 reefs surveyed showed evidence of bleaching.
- Fifteen known introductions and nine possible introductions of marine pests threaten Queensland's marine biodiversity.
- There are 83 endangered regional ecosystems in the coastal zone; 30% of these are along the Central Queensland Coast.
- A 10-year study on Milman Island showed an annual rate of decline of 3–4% in the nesting population of hawksbill turtles (approximately 4000 are estimated to nest in Queensland). The number of loggerhead turtles nesting in Queensland has declined to fewer than 3000 from an estimated population of 3500 in 1976–77. Both populations of green turtles on the Great Barrier Reef (total of about 38 000 nesting turtles) appear to be in the early stages of decline.
- Two species of marine fish are classified as critically endangered, three are classified as endangered and five are classified as vulnerable.
- Seagrass communities in Queensland have remained relatively stable over the past three years.



Cape Tribulation Section, Daintree National Park (Photo: EPA)

Biodiversity

The main pressures on Queensland's biodiversity are the clearing of remnant vegetation, changed fire regimes and the impacts of invasive species. While both the size of the protected area estate and the proportion of regional ecosystems represented in reserves increased between 1999 and 2002, there was a significant increase in the number of rare and threatened plant taxa. In particular:

- The clearing of remnant vegetation increased from an average of 446 000 ha/year in the period 1997–99 to 757 000 ha in 1999–2000, and then fell to 377 000 ha in 2000–01.
- The most heavily cleared areas in the period 1997–99 were the Brigalow Belt (260 000 ha), Mulga Lands (85 000 ha), Desert Uplands (51 100 ha) and Mitchell Grass Downs (27 000 ha).
- The ecosystem types with the lowest amount of pre-clearing extent remaining in 1999 were brigalow/gidgee (48%), rainforests/vine thickets (49%), subtropical woodlands (50%), and wet and dry sclerophyll forests (67%).
- More than 30% of northern Queensland (Gulf Plains, Northwest Highlands and Cape York Peninsula) was burnt between April 1998 and March 2000.
- In June 2002, 7 125 303 ha of land (4.1% of Queensland) was in protected areas, up from 7 058 946 ha (3.89%) in 1999.
- The proportion of regional ecosystems represented in reserves rose from 69% in 1999 to 74% in 2002.
- The proportion of bioregions in reserves ranges from 1.6% of the Mitchell Grass Downs to 13.3% of Cape York Peninsula and 19% of the Wet Tropics.
- While the number of threatened animals remained fairly stable between 1998 and 2002, in 2002 an additional 8 plant species were listed as presumed extinct, 68 as endangered, 34 as vulnerable, and 6 as rare.
- The majority of rare and threatened species are found in the Wet Tropics, Brigalow Belt, Southeast Queensland and Cape York Peninsula bioregions.
- Recovery plans have been prepared for 14% of the 588 threatened plants and animals listed under the *Nature Conservation Act 1992*.
- At least 1298 plants, 19 mammals, 13 birds, 15 fishes, 3 reptiles and 1 amphibian have become naturalised.
- Queensland has 15 of the 20 species listed as weeds of national significance and many more species are serious environmental weeds.
- The highest densities of introduced taxa are found in the New England Tableland, Wet Tropics, Central Queensland Coast and Southeast Queensland bioregions.
- Eighteen new plant naturalisations were recorded in Queensland in the period 1999–2001.



Dainty green tree frog (Photo: EPA)

Human settlements

Queensland's population is increasing, becoming more urbanised and increasingly concentrated in the state's south-east. While motor vehicle travel and overall energy use continue to increase, per capita water consumption appears to be stabilising and waste recycling is increasing. Although most Queenslanders are happy with their quality of life, the number of noise complaints has increased. In particular:

- Queensland's population grew by 8.9% from 3.34 million in 1996 to 3.63 million in 2001. The rate of population growth fell between 1996–2001 compared to 1991–96 but has risen rapidly since 2001.
- In 2001, 86.5% of Queenslanders lived in urban centres or localities, up from 83% in 1991.
- South-east Queensland accommodated 2.38 million people, or 65.4% of the state's population, in 2001. The region also accommodated 81.4% of the state's population growth over the period 1996–2001.
- Queensland's gross state product grew by an average of 4.7% a year over the period 1991–92 to 2001–02.
- Between 1993 and 2000, movement by road passenger vehicles increased by 28%, travel by rail increased by 20%, and road freight activity increased by 50%.
- Travel demand is growing faster than population. The number of passenger vehicles registered in Queensland increased from 1 680 713 (0.456 cars per capita) in 1998 to 1 836 529 (0.486 cars per capita) in 2002, the average distance travelled by passenger vehicles increased from 13 200 km in 1998 to 14 300 km in 2002.
- Between 1998 and 2002, total annual fuel consumption by all vehicles in Queensland increased by 22% to 5049 million litres.
- Public transport accounted for 10.1% of journeys to work in south-east Queensland in 2001, down from 11.3% in 1991.
- Average travel times during peak periods on the main roads into the Brisbane CBD rose by over 7% between 1998 and 2000.
- Queensland's total energy consumption rose from 849 petajoules (PJ) in 1994–95 to 1024 PJ in 2000–01.
- Queensland's main primary energy sources were black coal (45.8% of total energy use), petroleum products (37.1%), biomass (9.0%) and gas (7.6%).
- The proportion of Queensland homes using solar hot-water systems rose from 4.8% in 1994 to 9.1% in 2001.
- Average water consumption in the fourteen major urban water authorities in Queensland was 220 kilolitres/capita in 2000–01.
- The quantity of solid waste generated and sent to landfill in Queensland fell 13% from 4 428 800 tonnes (1350 kg/capita) in 1996–97 to 3 866 278 tonnes (1068 kg/capita) in 2001–02.
- The proportion of solid waste recycled in Queensland rose from 3.9% in 1996–97 to 20.4% in 2001–02.
- Approximately 87% of Queenslanders had access to a household recycling program in 2001–02. They recycled 150 449 tonnes of materials, or 41.6 kg/person.
- The volume of wastewater receiving tertiary treatment in south-east Queensland rose from 36% in 1998–99 to 48% in 2000–01.
- The proportion of wastewater reused in Queensland is low: an average of 5.7% in nine major urban local government areas.
- There were 12 956 noise complaints in 1999–2000, 18 655 in 2000–01 and 17 862 in 2001–02.
- Approximately 91% of Queenslanders surveyed in November 2001 said they were 'satisfied' or 'very satisfied' with their quality of life.
- Both Brisbane and the rest of Queensland saw a sharp decline in housing affordability in the period 2001–03.
- 4.6% of Queenslanders live in areas of relative disadvantage characterised by low income and high unemployment.
- Urban residential densities in South East Queensland increased 5.1% between 1995 and 2001. In response Local Governments are providing more open space and walkways.

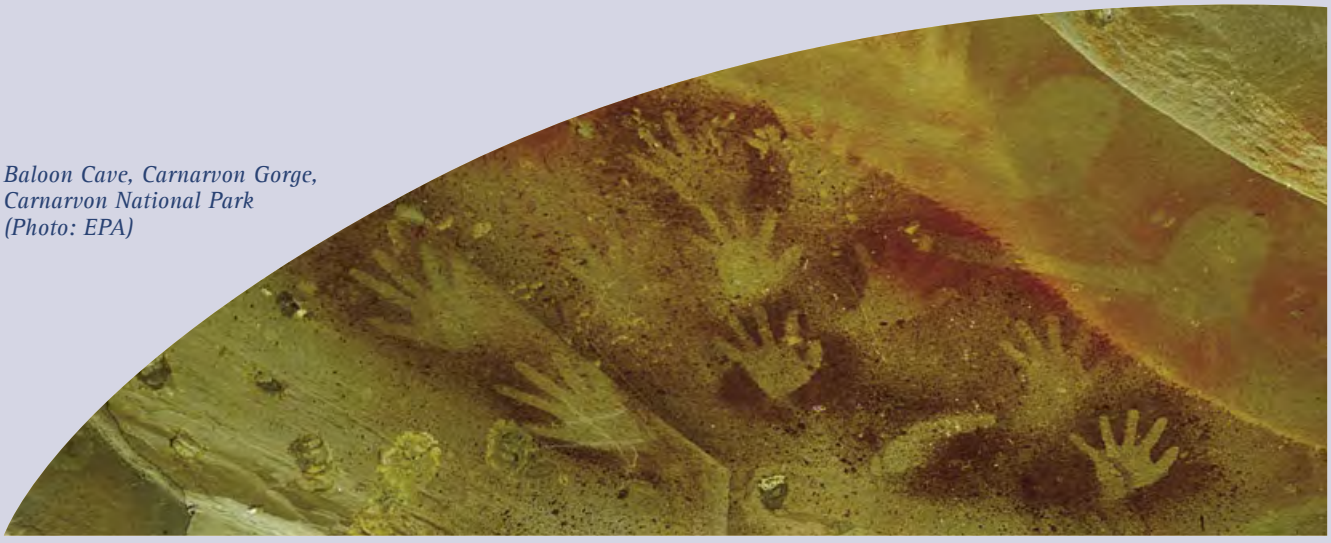


Human settlements (Photo: Tourism Queensland)

Natural and cultural heritage

Although knowledge of Queensland's heritage has increased since 1999, there has been no systematic statewide survey of heritage places. Queensland's heritage registers and inventories are dominated by places in highly developed areas and certain types of heritage places may be comparatively neglected. Indigenous heritage places are most at risk from impacts of the pastoral and mining industries and from urban and rural development. Queensland lacks a formal register of natural heritage places. There is a lack of information on the physical condition of heritage places and collections which is critical for their effective management and protection. While interest in Indigenous languages has increased, the number of Indigenous language speakers is decreasing. Indigenous people are becoming increasingly involved in the management of cultural heritage and protected areas at the local level. In particular:

- At 30 June 2002, Queensland had 329 natural heritage places, 742 historical heritage places and 157 Indigenous heritage sites in the Register of the National Estate.
- At the same date, 1332 places were entered in the Queensland Heritage Register, up 279 places since 30 June 1998.
- The Register of Historic Shipwrecks currently lists 1056 shipwrecks dating from 1790 to 1945 (up from 847 in 1999). The location of 7% of these wrecks has been verified.
- The EPA's Indigenous Sites Database recorded 16 660 Indigenous heritage places at 30 June 2002, an increase of 9137 places since 1999. Artefact scatters made up 38.9% of records, followed by paintings (12.1%) and shell middens (11.5%).
- The 2001 directory of Museums Australia (Queensland) listed 363 museums in the state. Over 2.26 million objects are held in major collecting institutions, an increase of 17 811 objects since 1999. Current storage space is either adequate or is being managed to deal with projected increases in the size of collections.
- All of Queensland's major collecting institutions have over 90% of their collections accessioned.
- There were 7 124 585 ha of land in Queensland's protected area estate at 30 June 2002, up 66 580 ha since 1999. This included the addition of 13 conservation parks and 36 nature refuges.
- Six Ramsar sites in or offshore from Queensland were listed at 30 December 2002, with the addition of the Coral Sea Reserves (1 729 700 ha) in November 2002.
- The 2001 Census found that a total of 5891 persons in Queensland speak an Australian Indigenous language at home, with a declining proportion of young speakers in two of the four strong languages identified.
- No native title determinations have been made on protected areas and no parks have been leased back to Traditional Owners under the *Aboriginal Land Act 1991* or the *Torres Strait Islander Land Act 1991*. However, there has been a doubling of the area of land under formal Indigenous management in the Wet Tropics World Heritage Area to 26 453 ha in 2002.
- Funding specified for World Heritage management increased between 1998 and 2002 but continues to meet only about 70 % of required expenditure.
- Membership numbers of natural and cultural heritage organisations provide an indication of the level of community support. The Queensland Conservation Council had over 50 affiliate organisations in 1999–2000, and 112 environmental groups have been identified in Queensland. At 30 June 2002, the National Trust of Queensland had over 10 000 members, an increase from 5855 members in 1991. An additional 86 historical heritage community organisations were identified in 2002.



Baloon Cave, Carnarvon Gorge, Carnarvon National Park (Photo: EPA)

1 Introduction

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Queensland in summary

Queensland's land resources lie between the latitudes 10°S and 29°S and the longitudes 138°E and 153°E. The total land area is 172.8 million hectares; of this, 54% is classified as tropical. The area within the state's administrative jurisdiction includes numerous coastal islands.

The mainland coastline extends about 6000 km, and features 1165 offshore islands and cays. The Great Barrier Reef, the most significant feature of the state's coastal zone, consists of 3400 separate coral reefs, shoals and other formations and extends more than 2300 km from Bramble Cay to Lady Elliot Island.

The state can be divided into four main landscape regions: the eastern highlands, the western plains, the north-western uplands and the coastal plain. Much of the eastern coastline consists of long, sandy beaches with sand dunes and high sand deposits. Almost the entire eastern coastline is overlooked by the Great Dividing Range, which rises in places to over 1000 m. By contrast, the Gulf of Carpentaria is surrounded by low-lying plains: during the wet season, sea and land may be difficult to demarcate.



The cassowary is one of Queensland's many species of wildlife. (Photo: EPA)

Queensland's soils, like those of the rest of Australia, are often ancient, highly weathered and leached of nutrients. The continent has been geologically stable, suffering little volcanic activity or creation of new land masses, for many millions of years.

Australia's most naturally diverse state, Queensland has 13 terrestrial and 14 marine bioregions, defined on the basis of broad patterns of biological and physical characteristics. These regions support more than 1000 ecosystem types, habitat for approximately 66% of Australia's known frog, reptile, bird and mammal species and 47% of its vascular plant species.

The state's terrestrial vegetation communities can be grouped into the broad categories of forests (including woodlands), arid shrublands, grasslands, heathlands and wetlands. The distribution of these communities is determined largely by soil type, rainfall and temperature. Native forests are found on approximately 28% of the state, and native grasses on 86%, in both open grassland and woodland settings. The coastal zone has over 2 million ha of seagrass, 447 000 ha of saltmarsh and 190 000 ha of mangroves.

Queensland also has a diverse cultural heritage, comprising everything we have from the past, including the recent past. It includes places we value for their association with the history of our communities. People from many different cultural backgrounds have come to live in Queensland and have left their imprint on its cities, towns and countryside in the form of cultural heritage places such as landscapes that are important for their scenic and recreational value or have special significance to Aboriginal and Torres Strait Islander peoples; grand buildings, which may be rare examples of architectural styles; ordinary cottages; industrial installations; and archaeological sites and other places that played important roles in our history. These places are important to our communities and to the nation as a whole, and enrich our sense of identity.

Climate

Most of the state north of a line linking Rockhampton, Longreach and Cloncurry has a tropical climate with a summer monsoon and a mild, dry winter with clear skies. The region to the south is subtropical with a warm, humid summer and a comparatively dry winter with clear skies. The inland region west of Longreach and Charleville is subtropical and arid and experiences temperature and rainfall extremes.

Across the state, summer rainfall declines with distance from the coast and winter rainfall declines with distance from the south. Rainfall varies highly from year to year, strongly influenced by the El Niño Southern Oscillation phenomenon. Seasonal variability is also high, most of the state's rainfall occurring in the summer months. The Wet Tropics area has the highest rainfall in Australia and more than 90% of its annual rainfall occurs between November and April. The Innisfail area receives more than 4000 mm a year due to its high relief and coastal location. In contrast, Birdsville has the lowest annual average rainfall nationwide, receiving about 200 mm a year.

Queensland is susceptible to harsh climatic conditions, including severe droughts and flooding, frosts, tropical cyclones and violent thunderstorms with damaging winds and hail. Climatic variability has a significant influence on the characteristics of Queensland's waters, coastal systems, vegetation and biodiversity and often exacerbates human-induced pressures.



Queensland is susceptible to severe weather. (Photo: EPA)



Awoonga High Dam, near Gladstone (Photo: DNRM)

Water resources

Queensland's drainage pattern is controlled mainly by the Great Dividing Range, a loosely arranged chain of mountains, hills and high country running roughly parallel to the east coast. Fresh water is scarce in much of the state, particularly west of the Great Dividing Range. Dry areas are also present along the narrow east coast strip—for example, in the area between Bowen and Townsville where the mountain ranges are low and set back from the coast.

Although mainly dry, Queensland produces 40–45% of Australia's runoff while representing only 20% of the nation's land area. These proportions highlight not only the aridness of the Australian continent but the seasonal nature of much of the rainfall and the large falls received by the relatively small Wet Tropics area.

About 76% of the discharge of all Queensland's rivers occurs in sparsely populated catchments that drain to the Gulf of Carpentaria and the Coral Sea north of Mackay: only 6% of mean annual river flows discharge to inland river systems. Few inland streams are perennial: during the dry season many are reduced to dry channels with remnant billabongs. High evaporation rates west of the Great Dividing Range reduce surface water availability even further.

Groundwater provides about 44% of total annual water use in the state. The single largest groundwater source in Queensland is the Great Artesian Basin, which underlies about 65% of the state and is the sole source of water for stock and domestic use in many western areas.

The scarcity and unreliability of rainfall have led to high levels of storage and diversion of surface water from rivers and storages and extraction of groundwater from artesian sources to meet human needs. Diversion has reached or exceeded sustainable levels in certain areas. Water extraction and river modification have affected natural flow regimes, water quality, aquatic ecosystems and fish migration.

Land and sea

Queensland's variety of landforms, forest and mineral resources and vegetation supports a wide range of economic uses, cultural values and intrinsic environmental benefits. Beef cattle and sheep graze about 85% of the state; crops account for about 2%. Protected areas including national parks occupy about 4%, while managed forests and timber reserves occupy about 2.5%. The remainder of the land is used for services, housing, industry and mining activities. Crown land, leasehold land and freeholding leases cover 83.4% of the state.

Coastal waters also provide a wide range of cultural values and economic uses. These include recreational and tourism activities, commercial shipping and fishing, a growing aquaculture industry, and, in some areas, wastewater disposal. Fisheries on the southern and central coast have been harvested for many years, while those of the more remote northern Great Barrier Reef region and the Gulf of Carpentaria have been developed only over the past three decades. Marine parks cover approximately 38% of coastal waters, although most of these parks are managed for multiple uses rather than providing complete protection.

The most evident impact of European settlement has been the clearing of native vegetation to make way for other land uses, particularly grazing and urban development. Almost half of Queensland's woody ecosystems have been cleared since European settlement, and clearing continues. Clearing and fragmentation of native habitat are major causes of biodiversity loss. Remnant patches may be so small that they are inadequate for long-term protection of biodiversity. Clearing has also contributed to soil loss and degradation in many areas. Inappropriate clearing or overgrazing of protective vegetation along many watercourses has resulted in a range of water quality problems.

The subsequent uses of cleared land have also had many detrimental effects on our environment. Intensive cropping and grazing have had a range of impacts on soil and vegetation quality. Excessive grazing (by domestic, feral and native herbivores), altered fire regimes, harvesting activities and pollution, alone or in combination, have contributed to losses and declines in biodiversity. The quality of water in many Queensland river systems, aquifers and nearshore waters has been adversely affected by stormwater runoff from both agricultural and urban areas and by industrial and sewage effluents. Catchment development is believed to have increased fine-grained sediment exports to nearshore waters by two to five times natural levels. At least 80% of wetlands in areas affected by urbanisation and intensive agriculture have been destroyed or seriously degraded, while wetlands in the remote north are relatively unaffected.

Fishing is the most readily identifiable economic and recreational use placing pressure on marine ecosystems. Several commercial and recreational fisheries show signs of over-exploitation. Indirect impacts such as seabed disturbance and discarded bycatch also cause concern. Impacts from the growing aquaculture and tourism industries are also significant.

The spread of exotic and displaced native species (as the result of European settlement and land and sea use practices) has had severe impacts. At least 50 vertebrate species, 1226 plant taxa and unknown numbers of invertebrates and micro-organisms have established self-sustaining populations throughout the state. These eat, compete with and displace both terrestrial and marine native plants and animals. Introduced plants and animals have caused extensive damage to grazing land, crops and soils, and are difficult and expensive to control.

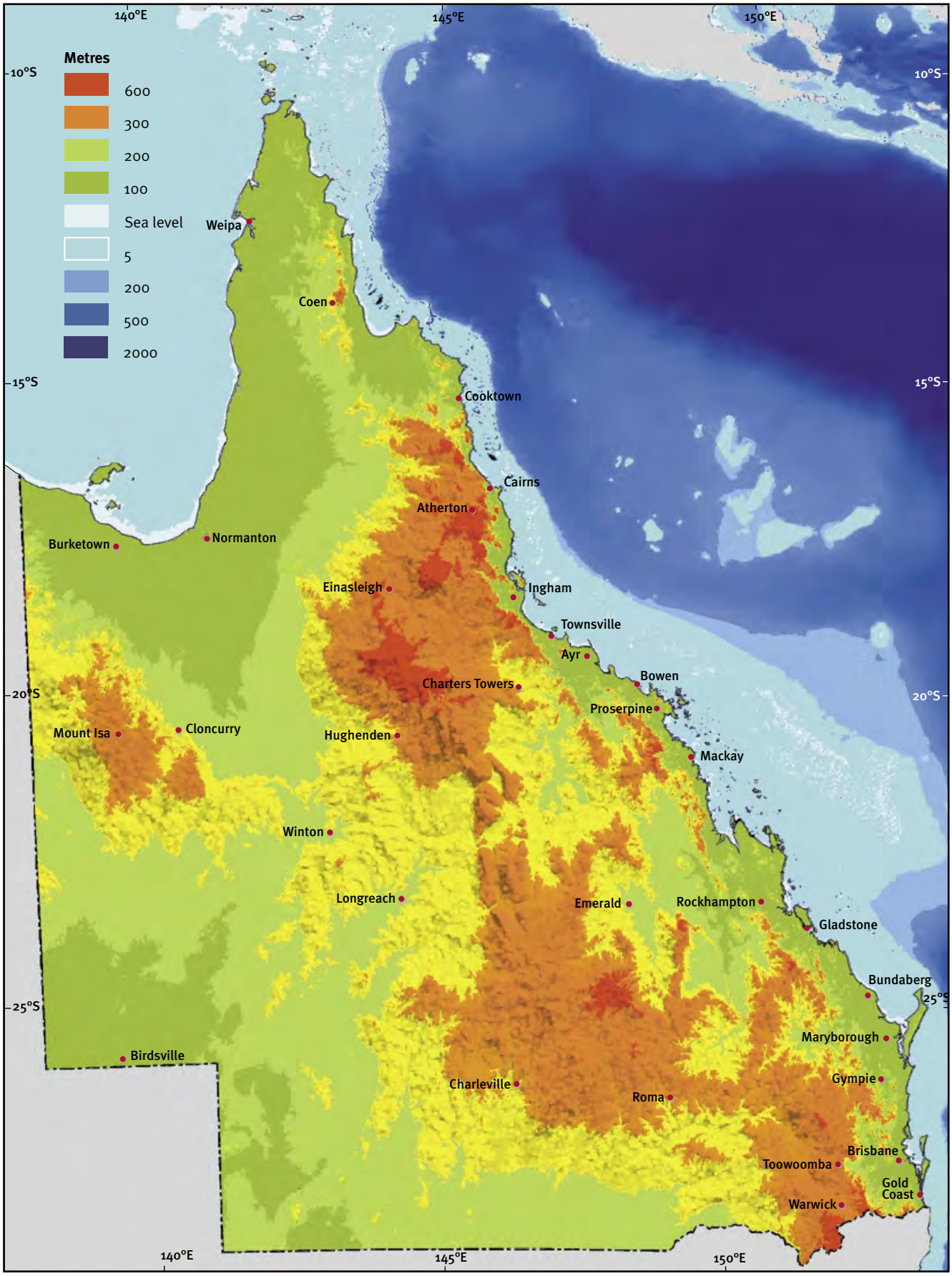


Figure 1.1 *Queensland in relief*

Forest, mineral and energy resources

About three-quarters of Queensland's forest cover is woodland. Closed forests are confined mainly to coastal areas and parts of southern inland Queensland. Almost all of the state's forest resource is native forest (99.6%). About 2.4 million ha of the 8.0 million ha of Crown reserves are used for commercial forest operations. Plantation forests cover only about 0.4% of total forest area but supply 61% of timber consumed in the state and this proportion is increasing.

Queensland has extensive mineral deposits. The Carpentaria–Mount Isa region in the state's north-west contains the major base metal deposits (particularly copper, lead, zinc and silver). The north and east of the state also contain a variety of deposits, including the majority of Queensland's gold and some base metals. Large bauxite deposits occur on Cape York Peninsula. The largest coal deposits are located in the Bowen Basin, which extends almost 500 km south from Collinsville. Queensland has extensive resources of most minerals currently mined, with the exception of mineral and silica sands.

The state's electricity and transport systems are reliant on fossil fuels, which contribute to greenhouse gases and atmospheric pollution. Queensland has a relatively high per capita use of energy. Electricity use rose by 135% between 1984–85 and 2000–01. The state has large coal reserves (which also support a major export industry), but only modest supplies of crude oil and natural gas. Crude oil reserves and production have been declining since the late 1980s. By 1996–97 the state's overall self-sufficiency in oil products had fallen to less than 10%. Significant sources of renewable energy (solar, wind, bagasse and biogas) are available in Queensland but currently meet a very small proportion of energy needs and remain largely undeveloped.



Queensland has extensive mineral deposits. (Photo: DNRM)

Human settlements

Queensland's average population density is very low—1.97 people/km²—but the majority of the population resides in the south-east. In 2001, 86.5% of Queenslanders lived in cities or urban areas. Population is concentrated on the coast where rainfall tends to be more frequent and reliable, where the beaches provide lifestyle and recreational opportunities, and where ports provided access in the early days of European settlement. West of the Great Dividing Range, population centres are small and scattered. Settlements in Queensland are well served by an extensive road network supported by a rail network serving the east coast and major inland centres.

The state's population increased by 8.9% between 1996 and 2001. Population increase is focused on established urban centres, particularly in south-east Queensland and on the coast in cities such as Townsville, Gladstone and Cairns. Rapid population increase is creating pressures to develop land and intensify land use. Tourism growth is placing further pressure on urban facilities and on natural and cultural heritage sites.

Low density or urban sprawl is characteristic of Queensland's population centres. As the population increases, there will be increasing pressures to develop land for urban purposes and consequent growth in transport needs. The increasing use of private motor vehicles will have particular implications for air pollution, energy use and greenhouse gas emissions. The impacts of waste, stormwater and sewage disposal, already significant in many human settlements, are likely to increase. The heritage values of places, buildings and objects are also threatened by development activity, particularly in the south-east and other urban growth centres.

Environmental management

Queensland's environmental values and natural resources are shared by all Queenslanders. As a consequence, all sectors of the community—government, industry, commerce, agriculture and each and every individual—have responsibility for environmental protection.

All three spheres of government—Commonwealth, state and local—have roles in environmental management and recent years have seen increasing levels of cooperation and resource-sharing among the spheres. The Commonwealth Department of Environment and Heritage focuses on issues of national environmental and cultural heritage significance. At the state level, the Environmental Protection Agency is the lead agency for all environmental management matters in Queensland, but many other government departments also have significant roles. Local governments also have extensive powers and responsibilities and play an important role in helping communities achieve economic, social and environmental outcomes. In particular, they provide water, sewerage and cleansing services and are responsible for land use planning, building control and waste management.

Governments are increasingly consulting and seeking participation from the private sector and the community in their planning, policy development and programs. Many environmental protection responses and activities exist outside government. Ecologically sustainable development needs to be pursued globally, nationally, regionally and individually. Community, industry and government responsibilities and responses to individual environmental issues are outlined in the following chapters of this report.



Queensland's population is concentrated along its coastline. (Photo: EPA)

This report

State of the environment reporting has arisen out of the worldwide recognition that our natural resources are under threat. Comprehensive reports on the environment are essential if we are to successfully manage it and conserve it for the future.

State of the environment reporting had its genesis in the United Nations Environment Programme (UNEP). Concern with environmental degradation had become a prominent social and political issue by the time UNEP was established. Most member countries of the OECD (Organization for Economic Cooperation and Development) now produce national state of the environment reports. In Australia, state of the environment reports are prepared by various shire and city councils as well as by most states and the Commonwealth.

State of the environment reports summarise and integrate available information on the condition of the environment in a form that is useful to decision makers, policy makers, planners and members of the broader community. They provide information on pressures affecting the environment and trends in its condition or quality. They also summarise society's responses to environmental problems.

Statutory requirements

State of the environment reporting is a statutory requirement under both the *Environmental Protection Act 1994* (the EP Act) and the *Coastal Protection and Management Act 1995* (the Coastal Act). The EP Act requirement applies to Queensland's environment generally, while the Coastal Act requirement relates specifically to the coastal zone.



The EPA is required to assess the state of the coastal zone. (Photo: EPA)

The Acts require the Environmental Protection Agency (EPA) to prepare an assessment of the state of the environment and of the coastal zone at least every four years. The EPA is Queensland's lead agency for environmental and conservation management matters. This report is designed to meet the requirements of both Acts.

Section 547 of the EP Act and section 102 of the Coastal Act specify that the report must:

- include an assessment of the condition of Queensland's major environmental resources (and major coastal resources);
- identify significant trends in environmental (and coastal) values;
- review significant programs, activities and achievements of persons and public authorities relating to the protection, restoration or enhancement of Queensland's environment (and coastal zone); and
- evaluate the efficiency and effectiveness of environmental (and coastal management) strategies implemented to achieve the objects of the Acts.

Environmental management and state of the environment reporting in Queensland

The EP Act states that the protection of Queensland's environment is to be achieved by an integrated management program that is consistent with ecologically sustainable development (ESD). ESD is defined in the EP Act as 'protecting the environment while allowing for development that improves the total quality of life, both now and in the future, in a way that maintains the ecological processes on which life depends'.

Under the EP Act, state of the environment reporting is an integral part of a four-phase planning and management cycle (figure 1.2).

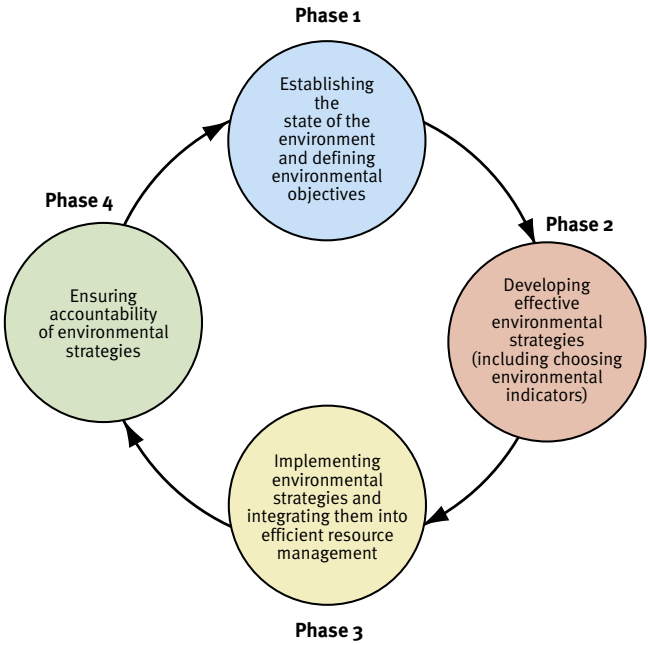


Figure 1.2 *The protection of Queensland's environment is to be achieved by an integrated management program that is consistent with ecologically sustainable development.*

Researching the state of the environment is part of phase 1. Reporting on the state of the environment is important to ensure accountability of environmental strategies and to provide objective measures of environmental performance and progress towards sustainability.

Aims of the report

This report builds on the information base established through *State of the Environment Queensland 1999* for developing sound environmental strategies and management and for assessing the sustainability of development in Queensland. It attempts to:

- identify existing knowledge on the state of the environment, including the main socioeconomic pressures affecting the environment;
- identify key indicators and data requirements for long-term monitoring;
- identify gaps in the available information;
- develop an appropriate reporting methodology;
- provide trend information on environmental quality and condition;
- create a system for tracking progress in environmental management and providing direction for policy development; and
- evaluate the efficiency and effectiveness of environmental strategies.

The report is designed for use principally by decision makers, planners and policy analysts in the private sector and government at the local, state and Commonwealth levels. It is hoped that the report will be a valuable resource for regional natural resource management bodies, community groups, students and the public generally.

Components of the report

The report has been published as three main documents:

- a summary of key findings;
- a report discussing the state of the environment in detail (this publication); and
- a report entitled *Implementing the Legislation*, an assessment of the effectiveness of the *Environmental Protection Act 1994* and the *Coastal Protection and Management Act 1995*.

Environmental themes of the report

The report is broad in scope, examining a range of physical, social and cultural elements and including resources such as water, minerals and forests. The chapters explore sustainability, the atmosphere, land, inland waters, the coastal zone, biodiversity, human settlements, and natural and cultural heritage. These thematic areas have been selected from the broad definition of the environment given in section 8 of the EP Act:

' "Environment" includes—

(a) ecosystems and their constituent parts, including people and communities; and

(b) all natural and physical resources; and

(c) the qualities and characteristics of locations, places and areas, however large or small, that contribute to their biological diversity and integrity, intrinsic or attributed scientific value or interest, amenity, harmony and sense of community; and

(d) the social, economic, aesthetic and cultural conditions that affect, or are affected by, the things mentioned in paragraphs (a) to (c).'

Pressure-condition-response framework

The report uses the 'pressure-condition-response' (PCR) framework developed by the OECD to explore key contemporary environmental issues for Queensland (figure 1.3).

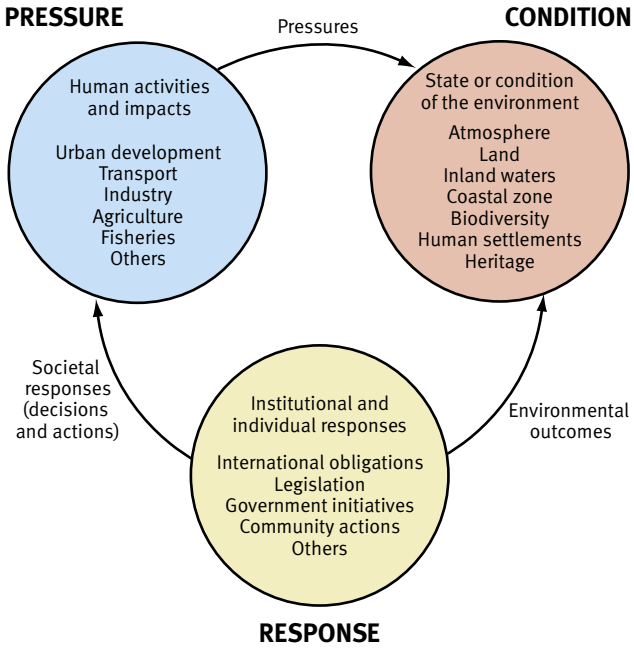


Figure 1.3 *The pressure-condition-response model used in state of the environment reporting*
Source: OECD

The PCR framework is based on the concept of causality: that is, human activities exert pressures on the environment and change its state or condition. Society responds to this changed state by various actions, policies and programs that directly affect the state of the environment or influence those human activities that exert pressure on the environment.

The information within chapters is treated under the headings 'Pressure', 'Condition' and 'Response', where possible. Discussion of each issue opens with a summary, which is followed by a brief description of the issue and possible effects on ecological health, human health, the economy and society. Case studies provide examples of successful management actions and innovations dealing with the environmental issue under discussion.

Summary tables use a report-card approach to present key condition and trend information.

Report preparation

The report was compiled by expert working groups established for each chapter. Members included research scientists, academics, government professionals and industry experts. The members of the working groups are listed at the beginning of each chapter. The chapters were prepared by the chapter authors and then reviewed by external expert referees, relevant Queensland Government departments and a statistician.

The EPA gratefully acknowledges the efforts of all authors, working group members and reviewers, without whose expertise and time this report would not be possible.

Data acquisition

A large volume of information, drawn from a wide range of sources, was collated, interpreted and used in this report.

Sources are cited throughout the text. Published citations can be found in the reference lists at the end of each chapter. Other sources are generally acknowledged by the use of organisational abbreviations. Abbreviations are explained in the glossary at the rear of the report. The EPA and chapter authors have provided additional data that may appear without specific acknowledgement.

Much of the information in this report has been provided by a wide range of organisations and individuals, both government and private, and the EPA gratefully acknowledges the use of the data.

Providing information at a regional scale

While there is currently insufficient information (and scope) to support detailed regional reporting within the report, an attempt has been made to provide the information at a regional scale where available. Ideally, the regional information presented within the report would be presented using the same basis for regionalisation: for example, local government areas, catchments or bioregions. This has not been possible within the limitations of the available data for this report. Where there are no constraints on how the data may be reported, natural resource management (NRM) regions have been chosen as the preferred regionalisation for the 2003 report. These natural resource management regions will be the basis for devolved funding, management and monitoring as part of the new integrated regional NRM planning processes and are likely to be a key source of future data.

As regional plans are developed there will be consideration of regional resource condition and trend, prioritisation of issues and the development of monitoring networks to support agreed management actions. A genuine attempt has been made within this report to collate the regional information available to support this process. This has been done to reflect the fact that these regions will be used to roll out major national natural resource management initiatives such as the National Action Plan and the second phase of the Natural Heritage Trust, NHT2, and given increased responsibility in ensuring delivery at a regional level. Figure 1.4 shows the regionalisations used and referred to in this report.

Future directions for state of the environment reporting

State of the environment reports are required in Queensland at least every four years. The EPA is currently reviewing its environmental reporting activities and information systems and is working towards an on-line system to enable the delivery of environmental information and statistics on a more regular basis. The EPA is keen to receive readers' views on whether the report meets their needs, and their suggestions for future reports.

You are invited to forward ideas by email to soe@epa.qld.gov.au, or in writing to:

Director-General
Environmental Protection Agency
PO Box 155, BRISBANE ALBERT STREET QLD 4002
AUSTRALIA

Links between chapters

Although the environmental themes are treated separately in individual chapters, many issues are interrelated. Most subjects are discussed largely within a single chapter in order to avoid undue duplication. Certain material can logically be discussed in more than one chapter: for example, land clearing and its effects on biodiversity, land resources and water quality are discussed in several chapters. Care has been taken to identify links and provide cross-references.

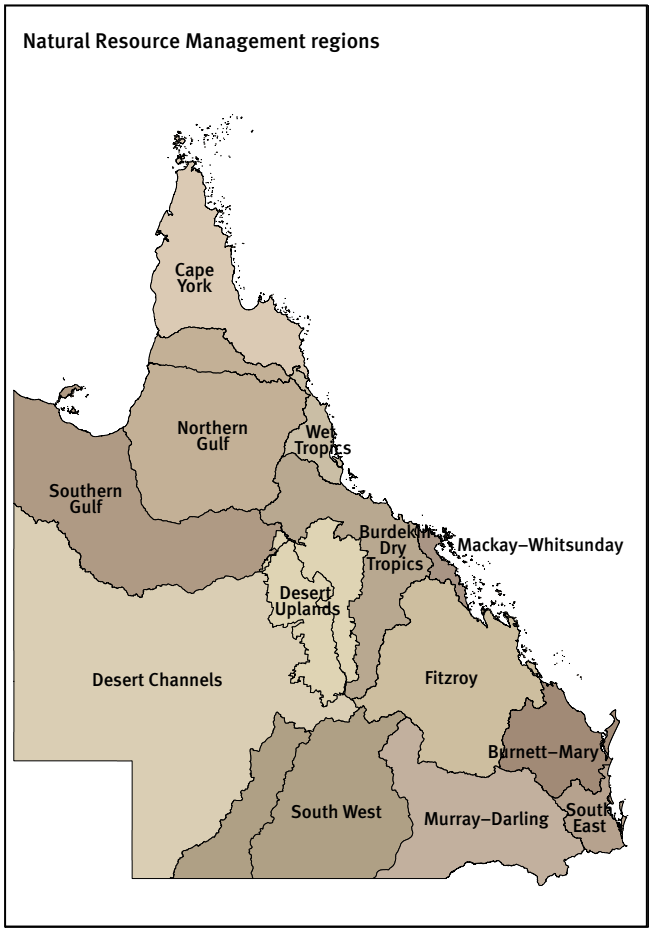
Environmental indicators

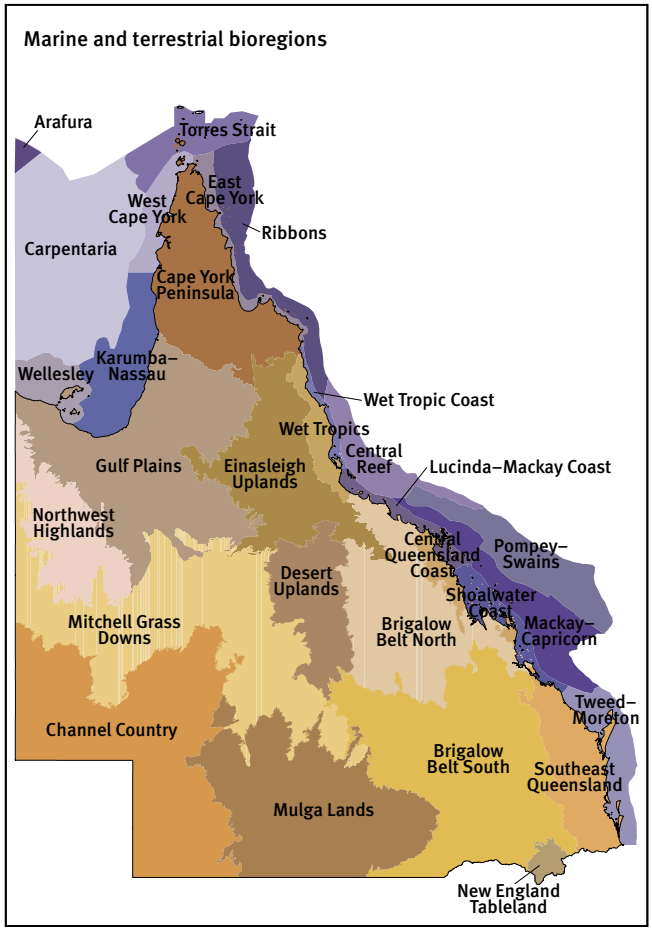
Indicators are used to characterise and inform environmental conditions, pressures and responses. An indicator is a physical, chemical, biological or socioeconomic measurement that provides a numerical indication of some aspect of an environmental issue.

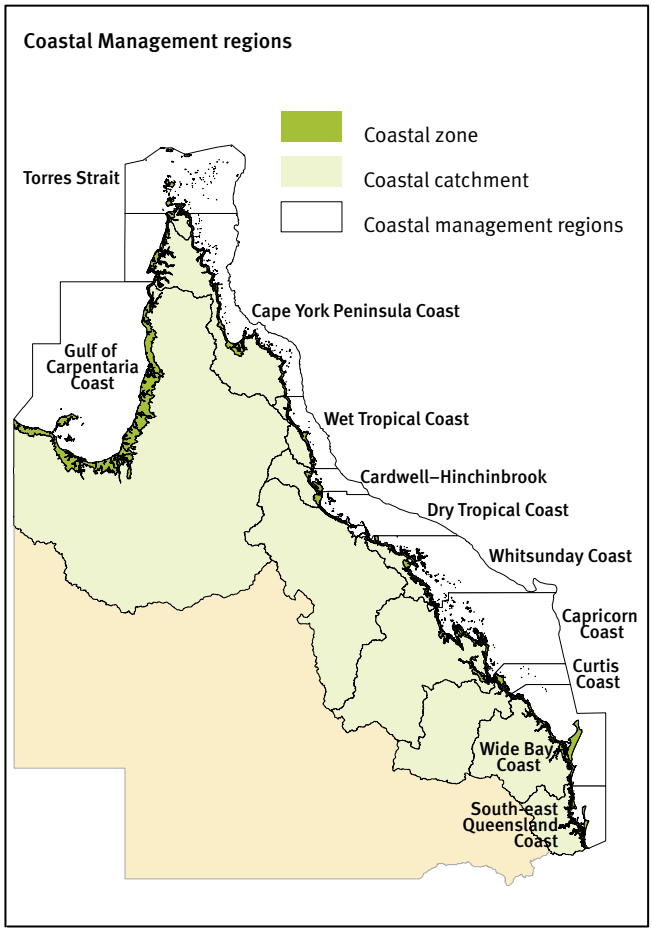
The indicators selected are a combination of the ANZECC Core Environmental Indicators and the state-specific indicators reported against in *State of the Environment Queensland 1999*. Table 1.1 lists the indicators used to compile this report.

Response indicators tend to be limited and provide a disjointed picture of levels of response activities. An overview of the primary legislative and strategic responses to each issue is provided. The effectiveness of these responses over time will be evident from changes in the environmental pressure and condition indicators.

Lack of data in many areas of the report has been a major problem. Data are not available for many of the indicators. These indicators are, however, listed in table 1.1 to identify information gaps that need to be filled to ensure effective assessments of environmental performance.







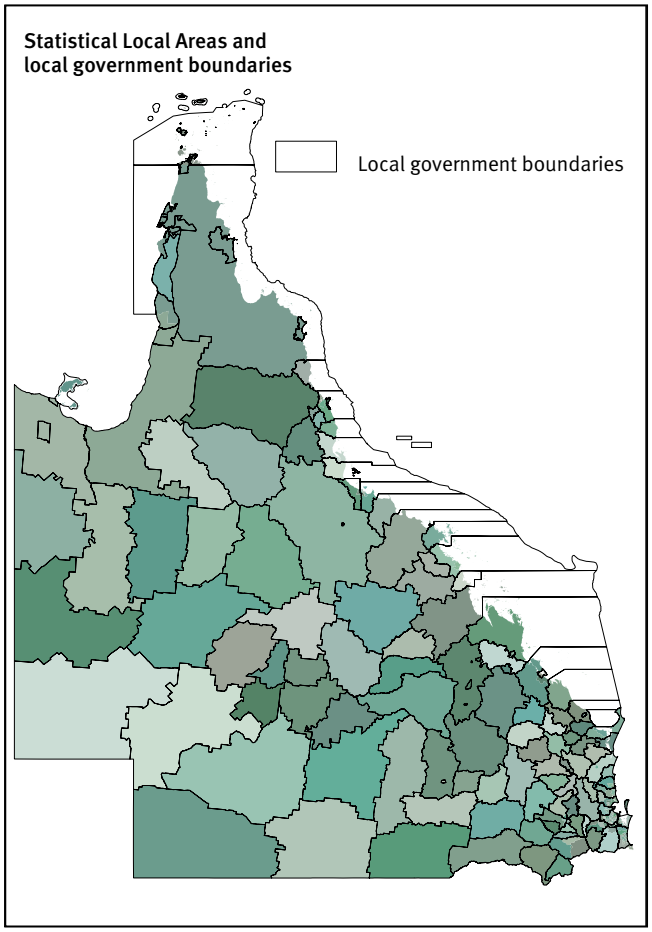


Figure 1.4 *Regionalisations used in this report*

Table 1.1 Issues and Indicators used to compile *State of the Environment Queensland 2003*

Key:
P = pressure, C = condition, R = response, Y = yes, N = no
ANZ- = Australian and New Zealand Environment and Conservation Council core environmental indicators: A = atmospheric, BD = biodiversity, L = land, IW = inland waters, ES = estuaries and seas, HS = human settlements
AusSoE01 = supplementary environmental indicators reported on in *Australia State of the Environment 2001*
QldSoE99 = state-specific supplementary environmental indicators reported on in *State of the Environment Queensland 1999*
QldSoE03 = state-specific environmental indicators not previously reported on included in *State of the Environment Queensland 2003*
For abbreviations and acronyms, see 'Glossary and abbreviations'.

THEME: ATMOSPHERE (Chapter 3)				
Issues	**Indicators**	**Reported**	**Primary responses (legislation and strategies)**	**Links to other themes/issues**
Climate variability	Southern Oscillation Index (C; ANZ-A1)	Y		Issue: Enhanced greenhouse effect
	Daily and extreme rainfall (C; ANZ-A2)	Y		
	Average maximum and minimum temperatures (C; ANZ-A3)	Y		
Enhanced greenhouse effect	Greenhouse gas atmospheric concentrations (C; ANZ-A4)	Y	National Greenhouse Strategy; Queensland Implementation Plan; Queensland Greenhouse Policy Framework: A Climate of Change	Issue: Climate variability
	Annual greenhouse gas emissions (P; ANZ-A5)	Y		
Stratospheric ozone depletion	Concentration of ozone-depleting substances in the atmosphere (P; ANZ-A6)	Y	*Ozone Protection and Synthetic Greenhouse Gas Management Act 1989* (Cwlth); *Environmental Protection Act 1994* and *Environmental Protection Regulation 1998*	Issue: Enhanced greenhouse effect
	Stratospheric ozone concentration (C; ANZ-A7)	Y		
	Recovery and destruction of ozone-depleting substances (R; ANZ-A8)	N		
	Ultraviolet radiation levels at the Earth's surface (C; ANZ-A9)	Y		
Photochemical smog	Exceedences of NEPM Air Quality Standards for ozone concentrations (photochemical smog) (C; ANZ-A11)	Y	Air NEPM (National Environment Protection Measure)	Issues: Other pollutants, Particle pollution and reduced visibility
Particle pollution and reduced visibility	Exceedences of Air EPP goal for visibility-reducing particles (C; QldSoE03)	Y	*Environmental Protection (Air) Policy 1997*; Air NEPM	Issues: Other pollutants, Photochemical smog
	Exceedences of NEPM Air Quality Standards for particulate concentrations (C; ANZ-A15)	Y		
Air toxics	Measured concentrations of toxic air pollutants (C; QldSoE03)	Y	Draft Air Toxics NEPM; *Environmental Protection (Air) Policy 1997*	Issue: Other pollutants
Other pollutants	Exceedences of NEPM Air Quality Standards for carbon monoxide concentrations (C; ANZ-A10)	Y	Air NEPM; National Pollutant Inventory NEPM (as varied June 2000)	Themes: Human settlements, Biodiversity Issues: Other pollutants, Photochemical smog, Particle pollution and reduced visibility, Air toxics
	Exceedences of NEPM Air Quality Standards for lead concentrations (C; ANZ-A12)	Y		
	Exceedences of NEPM Air Quality Standards for nitrogen dioxide concentrations (C; ANZ-A13)	Y		
	Exceedences of NEPM Air Quality Standards for sulfur dioxide concentrations (C; ANZ-A14)	Y		
	Emissions of air pollutants (total and trends for emission source sectors) (P; ANZ-A16)	Y		
	Vehicle kilometres travelled per person (or total VKT) (P; QldSoE03)	Y		
	Population growth rate (P; AusSoE01)	Y		
	Number and extent of bushfires and controlled burns (P; QldSoE03)	Y		
	Percentage of green sugarcane harvesting (R; QldSoE03)	Y		
THEME: LAND (Chapter 4)				
Issues	**Indicators**	**Reported**	**Primary responses (legislation and strategies)**	**Links to other themes/issues**
Land use	Native vegetation clearing (P; ANZ-BD1)	Y	*Land Act 1994*; *Land Regulation 1995*; *Vegetation Management Act 1999*; *Aboriginal Land Act 1991*; *Aboriginal Land Regulation 1991*; *Torres Strait Islander Land Act 1991*; *Torres Strait Islander Land Regulation 1991*; *Aborigines and Torres Strait Islanders (Land Holding) Act 1985*; *Forestry Act 1959*; *Forestry (State Forests) Regulation 1987*; *Forestry Regulation 1998*; *Recreation Areas Management Act 1988*; *Integrated Planning Act 1997*; Aboriginal and Torres Strait Islander Policy; South East Queensland Regional Forest Agreement	Themes: Human settlements, Atmosphere, Biodiversity, Towards sustainability Issue: Salinity
	Changes in land use (P; ANZ-L1)	Y		
	Agricultural land subdivided for urban housing (C; QldSoE99)	Y		
	New allotments for housing (C; QldSoE99)	N		
Climate variability and pasture production	Southern Oscillation Index (C; ANZ-A1)	Y		Theme: Atmosphere Issue: Climate variability
	Daily and extreme rainfall (C; ANZ-A2)	Y		
	Average maximum and minimum temperatures (C; ANZ-A3)	Y		

Issues	Indicators	Reported	Primary responses (legislation and strategies)	Links to other themes/issues
Mining disturbance	Cumulative areas of land disturbance and rehabilitation (C; QldSoE99)	Y	*Environmental Protection Act 1994*; Mining Agreement Acts	
	Number of abandoned minesites (C; QldSoE99)	Y		
	Production of principal metallic minerals and fuel minerals (P; QldSoE99)	Y		
	Number, location and type of operating mines, quarries and petroleum projects (P; QldSoE99)	Y		
	Area covered by mining, exploration and petroleum tenements (P; QldSoE99)	Y		
	Rate of rehabilitation of existing mines (R; QldSoE03)	Y		
	Rate of rehabilitation of abandoned mines (R; QldSoE03)	Y		
Salinity	Area of rising watertables (C; ANZ-L4)	Y	*Land Act 1994*; *Vegetation Management Act 1999*; *Vegetation Management Regulation 2000*; *Water Act 2000*; National Action Plan for Salinity and Water Quality; Natural Heritage Trust	
	Area of land affected by dryland salinity (C; ANZ-L5)	Y		
	Area of land affected by irrigation salinity (C; QldSoE99)	Y		
	Irrigated area (P; QldSoE99)	Y		
	Changes in land use (P; ANZ-L1)	Y		
Water erosion	Water erosion hazard ratings (C; ANZ-L2)	Y	*Soil Conservation Act 1986*; *Soil Conservation Regulation 1998*; *Environmental Protection Act 1994*; National Action Plan for Salinity and Water Quality	Issue: Wind erosion
	Rate of soil loss from water erosion (C; QldSoE99)	Y		
	Area under bare-surface production systems (P; QldSoE99)	Y		
	Grazing pressures (P; QldSoE99)	Y		
	Actual stocking rates compared to carrying capacity (P; QldSoE99)	Y		
	Percentage of cropped land with reduced tillage plus stubble retention by agro-ecological region (R; ANZ-L1.9A)	Y		
Wind erosion	Frequency of occurrence of dust events (C; ANZ-L3)	Y	ANZECC Dust Storm Index	Issue: Water erosion
	Difference between measured wind erosion rates and rates predicted by climatic conditions—Accelerated Erosion Index (C; QldSoE99)	Y		
	Domestic vertebrate grazing pressure per landcover region and agro-ecological region (P; ANZ-L1.2A)	Y		
	Non-domestic vertebrate herbivores per landcover region and agro-ecological region (P; ANZ-L1.2B)	Y		
Mass movement	Areas affected by soil mass movement (C; QldSoE99)	Y	*Integrated Planning Act 1997*; *Vegetation Management Act 1999*; *Land Act 1994*; Emergency Management Australia; Natural Heritage Trust	Theme: Biodiversity
	Areas of vegetation clearance on slopes (P; QldSoE03)	Y		
	Areas zoned as being potentially hazardous for habitation (hazard assessment) (R; QldSoE03)	Y		
	Areas (slopes) revegetated (R; QldSoE03)	Y		
Agricultural soil acidification	Area affected by acidity (C; ANZ-L6)	Y	National Land and Water Resources Audit	Issue: Soil fertility decline and soil carbon
	Area of cropping land with naturally acidic surface soil or with high rates of acidification (C; QldSoE99)	Y		
	Fertiliser application rates and yield (P; QldSoE99)	Y		
	Area of cultivated land with high rates of application of ammonia-based nitrogen fertilisers (P; QldSoE99)	Y		
	Lime and dolomite application rates (R; QldSoE03)	Y		
Soil fertility decline and soil carbon	Nutrient balance (C; QldSoE03)	Y		Issue: Agricultural soil acidification
	Trends in soil fertility yield (C; QldSoE03)	Y		
	Product quality (wheat protein) (C; QldSoE03)	Y		
	Fertiliser application rates and yield (P; QldSoE99)	Y		
	Market prices of fertilisers/products (P; QldSoE99)	Y		
	Trends in fertiliser use (R; QldSoE03)	Y		
	Exceedences of maximum residue levels in food and produce (C; ANZ-L7)	N		
	Area of ley cropping (R; QldSoE03)	Y		
Soil compaction	Area affected by soil structure decline (C; QldSoE99)	Y	Controlled traffic	
	Soil bulk density (C; QldSoE03)	Y		
	Extent of cropping and sown pasture activities (P; QldSoE99)	Y		
	Trend in size of tractors (R; QldSoE03)	Y		

Issues	Indicators	Reported	Primary responses (legislation and strategies)	Links to other themes/issues
Contaminated land	Number of development applications by local government area (C; QldSoE03)	Y	Assessment of Site Contamination NEPM; *Environmental Protection Act 1994*	
	Volume of contaminated soil disposed of (C; QldSoE03)	Y		
	Number of contaminated sites (P; QldSoE03)	Y		
	Number of development applications for contaminated land matters (P; QldSoE03)	Y		
	Quantity of soil requiring disposal to landfills (P; QldSoE03)	Y		
	Number of contaminated sites remediated (and removed from the register) (R; QldSoE03)	Y		
	Number of site management plans approved (R; QldSoE03)	Y		
	Number of sites with environmentally relevant activities licensed (R; QldSoE03)	Y		
Pasture condition	Proportion of pastures recognised as being in a desirable condition (C; QldSoE99)	Y	*Land Act 1994*; *Integrated Planning Act 1997*; *Vegetation Management Act 1999*; *Land Protection (Pest and Stock Route Management) Act 2002*; *Stock Amendment Act 1993*; Draft State Rural Leasehold Land Strategy	Theme: Biodiversity
	Proportion of pastures with a high utilisation (P; QldSoE03)	Y		
	Proportion of pastures invaded by undesirable species (P; QldSoE03)	Y		
Weeds and pests	Number, density and distribution of noxious plant species (C; QldSoE99)	Y	*Land Protection (Pest and Stock Route Management) Act 2002*; *Rural Lands Protection Act 1985*; *Nature Conservation (Wildlife) Regulation 1994*; National Feral Animal Control Program; State Pest Animal Strategy; National Weed Strategy	Theme: Biodiversity
	Number of established feral animal species and their distribution (C; QldSoE99)	Y		
	Number of introduced and naturalised plant species (P; QldSoE99)	Y		
	Number of introduced animal species (P; QldSoE99)	Y		
	Number of local governments with pest management plans (R; QldSoE03)	Y		
	Number of biological control agents released (R; QldSoE03)	Y		
THEME: INLAND WATERS (Chapter 5)				
Issues	**Indicators**	**Reported**	**Primary responses (legislation and strategies)**	**Links to other themes/issues**
GROUNDWATER				
Groundwater—subartesian water levels	Artesian and subartesian water extraction rates versus availability (P; ANZ-IW1)	Y	*Water Act 2000*	Issues: Groundwater quality, Surface water quality
	Groundwater levels (C; QldSoE03)	Y		
	Introduction of water resource plans (R; QldSoE03)	Y		
Groundwater—artesian bore pressure	Number of uncontrolled artesian bores (P; QldSoE03)	Y	Great Artesian Basin Sustainability Initiative	
	Total length of bore drains (P; QldSoE03)	Y		
	Trend in artesian bore pressure (C; QldSoE03)	Y		
	Number of artesian bores capped (R; QldSoE03)	Y		
	Groundwater use efficiency measures—length of bore drains piped (R; QldSoE03)	Y		
Groundwater quality	Land clearing—extent of deep-rooted vegetation cover by catchment (P; ANZ-IW3)	Y	*Environmental Protection Act 1994*; *Water Act 2000*; National Water Quality Management Strategy; National Action Plan for Salinity and Water Quality	Theme: Land Issues: Groundwater—subartesian water levels, Surface water quality
	Rural and urban development (P; QldSoE03)	Y		
	Stream regulation and land irrigation (P; QldSoE03)	Y		
	Exceedences of groundwater quality guidelines (C; ANZ-IW2)	Y		
SURFACE WATER				
Surface water quantity	Surface water extraction rates (approvals of licence applications) (P; QldSoE03)	Y	*Water Act 2000*; *Murray–Darling Basin Act 1996*; *Water Regulation 2002*; Queensland Water Recycling Strategy	
	Surface water extraction versus availability (P; ANZ-IW4)	Y		
	Irrigation: water use by sector, area irrigated (P; QldSoE03)	Y		
	Mean annual flow, percentage of natural/pre-development (C; QldSoE03)	Y		
	Variability of flow (APFD or equivalent) (C; QldSoE03)	Y		
	Storage capacity (as percentage of median annual runoff) (C; QldSoE03)	Y		
	Introduction of WRPs/ROPs (environmental flow objectives, number of plans, areal coverage) (R; ANZ-IW5)	Y		
	Introduction of land and water management plans (R; QldSoE03)	Y		
	Regulation of overland flow (R; QldSoE03)	Y		
	Increase in wastewater reuse (where appropriate) (R; ANZ-IW11)	Y		

Issues	Indicators	Reported	Primary responses (legislation and strategies)	Links to other themes/issues
Surface water quality	Discharges of pollutants into waterways from point sources (P; ANZ-IW6)	Y	*Water Act 2000*; *Environmental Protection Act 1994*; *Environmental Protection (Water) Policy 1997*; National Water Quality Management Strategy; National Action Plan for Salinity and Water Quality	Theme: Land (soil fertility decline and soil carbon) Issues: Groundwater—subartesian water levels, Groundwater quality
	Land practices, use of chemical fertilisers and pesticides (P; QldSoE03)	Y		
	Land clearing—extent of deep-rooted vegetation cover by catchment (P; ANZ-IW3)	Y		
	Riparian zone condition (P; QldSoE03)	Y		
	Livestock access to streams (P; QldSoE03)	Y		
	River regulation, construction sites, sand and gravel extraction and mining (P; QldSoE03)	Y		
	Water abstraction (P; QldSoE03)	Y		
	Assessment of surface water quality parameters (salinity, pH, total N, total P, turbidity, pesticides) by catchment and in critical problem areas (C; ANZ-IW7, IW8)	Y		
	Assessment of secondary surface water quality parameters (dissolved oxygen, sediment, nutrients, toxicants and faecal contaminants) (C)	Y		
	Incidences of algal blooms (C; ANZ-IW9)	Y		
	Extent and type of wastewater treatment—improved level of sewage and industrial wastewater treatment (e.g. from secondary to tertiary) (R; ANZ-IW10)	N		
	Development of major water resource management initiatives (R; QldSoE03)	Y		
	Implementation of urban stormwater and effluent management plans by local governments (R; QldSoE03)	Y		
	Extent of community participation (e.g. Landcare, Waterwatch, catchment management groups) (R; QldSoE03)	Y		
AQUATIC ECOSYSTEMS				
Aquatic ecosystems—riverine habitat	Clearing of stream riparian vegetation, reduction of riparian widths (P; QldSoE03)	Y	*River Improvement Trust Act 1940*; *River Improvement Trust Regulation 1998*; *Vegetation Management Act 1999*	
	Destruction of natural stream aquatic habitats (P; ANZ-BD2)	Y		
	Decline of river physical integrity (fragmentation, increasing lengths of river impoundment, channelisation etc.) (P; QldSoE03)	Y		
	Vegetated stream length (C; ANZ-IW12)	Y		
	Extent and condition of aquatic habitat (C; ANZ-BD8)	Y		
	Macro-invertebrate indices (C; ANZ-IW13)	Y		
	Estimated spread of exotic flora (C; QldSoE03)	Y		
Aquatic ecosystems—wetlands	Wetland protection measures and restoration rates (R; QldSoE03)	Y	*Nature Conservation Act 1992*; Strategy for the Conservation and Management of Queensland's Wetlands	
	Reduction in wetland cover (P; QldSoE03)	Y		
	Extent, diversity and condition of wetlands (C; ANZ-IW14)	Y		
Aquatic ecosystems—fish	Barriers to movement of aquatic biota (P; QldSoE03)	Y	*Fisheries Act 1994*; Fisheries (Freshwater) Management Plan; Control of Exotic Pest Fish	
	Estimated spread of exotic biota (flora and fauna) (P; QldSoE03)	Y		
	Commercial and recreational fishing (P; QldSoE03)	Y		
	Status of fish stocks (C; ANZ-IW15)	Y		
	Macro-invertebrate biodiversity (richness) indices (C; QldSoE03)	Y		
	Distribution of endangered and iconic aquatic species (C; QldSoE03)	Y		
	Restoration of passage (R; QldSoE03)	Y		
	Implementation of pest plant and animal strategies (e.g. Exotic Pest Fish Strategy) (R; QldSoE03)	Y		
	Limits to harvest (R; QldSoE03)	Y		

THEME: THE COASTAL ZONE (Chapter 6)				
Issues	**Indicators**	**Reported**	**Primary responses (legislation and strategies)**	**Links to other themes/issues**
Coastal resource use and development	Changes in coastal use compared with 1999 where possible. Area of land in the coastal zone in the natural state (by habitat type—wetlands, mangroves, saltmarsh, melaleuca, intertidal flats, dune vegetation). Area of land in the coastal zone in other than natural state (by land use—urban, agricultural, plantation, public, private etc.). Lineal extent of land developed (i.e. changed from natural) along the coastline (P; ANZ-ES1)	Y	*Coastal Protection and Management Act 1995*; *Beach Protection Act 1968*; State Coastal Plan	
	Total number and percentage of state's population living in the coastal zone (P; QldSoE99)	Y		
	Annual average population growth by local government area (P; QldSoE99)	Y		
	Annual cargo throughput for Queensland ports (P; QldSoE99)	Y		
	Annual tonnage of petroleum products moved by sea (imports and exports) (P; QldSoE99)	Y		
	Annual number of pollution incidents in Queensland's territorial waters and offshore reported to the Australian Maritime Safety Authority (P; QldSoE99)	Y		
	Number and areal extent of approved extractive activities (by type, e.g. silica and mineral sands) for each coastal region (tidal and non-tidal) (C; QldSoE99)	Y		
	Visitor bed numbers in the coastal zone (P, R; QldSoE99)	Y		
	Number of visitor permits to coastal and marine parks (including Great Barrier Reef Marine Park) (C, P: QldSoE99)	Y		
	Number of recreational (motor and sail) and commercial vessels registered in Queensland (P; QldSoE99)	Y		
	Total seafood catch (total catch and effort by species of commercial fish, crustacean and mollusc species) (P; ANZ-ES3)	Y		
	Recreational fish catch and effort (P; QldSoE99)	Y		
	Annual total bycatch by fishery (commercial) (P; QldSoE99)	Y		
	Area of seabed trawled and intensity of trawling (P; QldSoE99)	Y		
	Number of authorities to collect aquarium fish (P; QldSoE99)	Y		
	Number of permits to collect shells (and total volume) (P; QldSoE99)	Y		
	Areal extent of declared fish habitat areas (R; QldSoE99)	Y		
	Turtle, dugong and dolphin mortality through commercial fishing activity, shark nets and Indigenous hunting (P; QldSoE99)	Y		
	Area of coast in each coastal region under aquaculture ponds/cage facilities (C, P; QldSoE99)	Y		
Coastal water quality	Annual aquaculture production (by type) (P; QldSoE99)	Y	*Environmental Protection Act 1994*; *Environmental Protection (Water) Policy 1997*; *Transport Operations (Marine Pollution) Act 1995*; *Transport Operations (Marine Pollution) Regulation 1995*; *Integrated Planning Act 1997*	
	Bioaccumulated pollutants (C; ANZ-ES8)	Y		
	Algal blooms in estuarine and marine environments (C; ANZ-ES9)	Y		
	Coastal discharges (quantity of nitrogen, phosphorus, sediments and other contaminants discharged per catchment area for each coastal region) (P; ANZ-ES5)	Y		
	Marine pollution incidents (P; ANZ-ES6)	Y		
	Exceedences of marine and estuarine water quality guidelines (C; ANZ-ES7)	Y		
	Wastewater treatment—coastal waters. Discharge volume of primary, secondary and tertiary treated effluent (domestic and industrial sewage) into coastal waters (C, R; ANZ-ES10)	Y		
Coastal habitats and biodiversity	Disturbance of acid sulfate soils (P; ANZ-ES11)	Y	*Coastal Protection and Management Act 1995*; State Coastal Plan	
	Disturbance of marine habitat (P; ANZ-ES2)	Y		
	Estimated wild fish stocks (P; ANZ-ES4)	Y		
	Extent and diversity of estuarine, coastal and marine habitats (mangrove area, saltmarsh area, seagrass area and changes since 1999, coral reef area, dune vegetation) (C; ANZ-ES2)	Y		
	Number and type of marine and terrestrial pest and displaced species identified as of concern in each coastal region (C; QldSoE99)	Y		
	Ship arrivals from foreign ports and ballast water discharged to Queensland waters (P; QldSoE99)	Y		

Issues	Indicators	Reported	Primary responses (legislation and strategies)	Links to other themes/issues
Coastal variability—physical processes	Sea level (and wave variability) (C; ANZ-ES12)	Y	*Beach Protection Act 1968*; *Tweed River Entrance Sand Bypassing Project Agreement Act 1998*	
	Sea surface temperature variability (C; ANZ-ES13)	Y		
	Storm surge height (C; QldSoE99)	Y		
	Number and intensity of cyclone events for each coastal region (C; QldSoE99)	Y		
THEME: BIODIVERSITY (Chapter 7)				
Issues	**Indicators**	**Reported**	**Primary responses (legislation and strategies)**	**Links to other themes/issues**
Habitat protection	Native vegetation clearing and modification (P; ANZ-BD1)	Y	*Environment Protection and Biodiversity Conservation Act 1999* (Cwlth); *Great Barrier Reef Marine Park Authority Act 1975*; *Land Act 1994*; *Vegetation Management Act 1999*; *Vegetation Management Regulation 2000*; *Marine Parks Act 1982*; *Marine Parks Regulation 1990*; *Wet Tropics World Heritage Protection and Management Act 1993*; *Wet Tropics Management Plan 1998*; *Nature Conservation Act 1992*; *Nature Conservation (Protected Areas) Regulation 1994*; *Fisheries Act 1994*	Issue: Coastal habitats and biodiversity
	Fire regimes (P; ANZ-BD3)	Y		
	Extent and condition of native vegetation (C; ANZ-BD7)	Y		
	Terrestrial, marine and estuarine protected areas (R; ANZ-BD10, 11)	Y		
	Area revegetated (R; ANZ-BD13)	Y		
Species protection	Vegetation planning (R; QldSoE03)	Y	*Nature Conservation Act 1992*; *Nature Conservation Regulation 1994*; *Nature Conservation (Wildlife) Regulation 1994*; *Fisheries Act 1994*; Nature Conservation Plans; National Strategy for the Conservation of Australia's Biological Diversity	Issue: Coastal habitats and biodiversity
	Extinct, endangered and vulnerable species and ecological communities (C; ANZ-BD6)	Y		
	Populations of selected species (C; ANZ-BD9)	Y		
	Recovery plans (R; ANZ-BD12)	Y		
Pest species	Introduced species (P; ANZ-BD4)	Y	*Land Protection (Pest and Stock Route Management) Act 2002*; *Rural Lands Protection Act 1985*	Theme: Land Issues: Weeds and pests, Coastal habitats and biodiversity
	Species outbreaks (P; ANZ-BD5)	Y		
THEME: HUMAN SETTLEMENTS (Chapter 8)				
Issues	**Indicators**	**Reported**	**Primary responses (legislation and strategies)**	**Links to other themes/issues**
Population and settlement pattern	Total population (P; QldSoE99)	Y	*Integrated Planning Act 1997*; State Coastal Plan	Issue: Coastal resource use and development
	Population growth rate (P; AusSoE01)	Y		
	Net natural increase and net migration (P; QldSoE99)	Y		
	International migration (P; AusSoE01)	Y		
	Visitor numbers and nights (P; QldSoE99)	Y		
	Visitor numbers (P; ANZ-HS7, AusSoE01)	Y		
	Percentage (regional) population change (P; QldSoE99)	Y		
	Population distribution (C; ANZ-HS6)	Y		
	Residential density (C; ANZ-HS5, AusSoE01)	Y		
	Integrated planning at the state, regional and local levels (R; QldSoE03)	Y		
	Managing development (R; QldSoE03)	Y		
Economic activity and employment	Economic growth (P; QldSoE03)	Y	*Integrated Planning Act 1997*; State Infrastructure Plan	
	Gross domestic product (P; AusSoE01)	Y		
	Distribution of economic activity (P; QldSoE03)	Y		
	Unemployment rates (C; AusSoE01)	Y		
	Information economy (R; AusSoE01)	Y		
Travel and transport	Number of motor vehicles by population (P; QldSoE99)	Y	*Integrated Planning Act 1997*; Regional Integrated Transport Plans	Theme: Atmosphere
	Distance travelled by type of vehicle (P; QldSoE99)	Y		
	Average trip length (C; QldSoE99)	Y		
	Total time and distance travelled (C; AusSoE01)	Y		
	Fuel consumption (P; QldSoE99)	Y		
	Fuel consumption per transport output (P; ANZ-HS9, AusSoE01)	Y		
	Mode of transport to work or study (C; QldSoE99)	Y		
	Public transport patronage by mode (C; QldSoE99)	Y		
	Proportion of households with access to public transport (C; QldSoE99)	Y		
	Public transport use (C; ANZ-HS8)	Y		
	Average speed of travel on roads (C; QldSoE99)	Y		
	Cost of congestion (C; AusSoE01)	Y		

Issues	Indicators	Reported	Primary responses (legislation and strategies)	Links to other themes/issues
Consumption of resources	Land converted from non-urban to urban uses (P; AusSoE01)	Y	*Integrated Planning Act 1997*; *Water Act 2000*; *Queensland Energy Policy*	Theme: Inland waters
	Per capita energy use (C; QldSoE99)	Y		
	Municipal household water consumption patterns (C; AusSoE01)	Y		
	Household energy use (C; QldSoE99)	Y		
	Energy use (C; ANZ-HS1)	Y		
	Total energy use (C; AusSoE01)	Y		
	Energy sources (P; ANZ-HS2)	Y		
	Renewable energy (AusSoE01)	Y		
Waste outputs	Solid waste generated per capita (C; QldSoE03)	Y	*Integrated Planning Act 1997*; *Environmental Protection Act 1994*; *Environmental Protection (Waste Management) Policy 2000*; *Environmental Protection (Waste Management) Regulation 2000*; *Environmental Protection Regulation 1998*; Queensland Water Recycling Strategy	Theme: Inland waters Issue: Contaminated land
	Wastewater generated per capita (C; QldSoE03)	Y		
	Amount of solid waste by source (P; QldSoE99)	Y		
	Solid waste generation and disposal (P; ANZ-HS10)	Y		
	Volume of liquid waste (C; QldSoE99)	Y		
	Wastewater discharged (P; AusSoE01)	Y		
	Waste recovered/recycled (R; AusSoE01)	Y		
	Wastewater reused by type of application (R; AusSoE01)	Y		
Liveability	Number of noise complaints (P; QldSoE99)	Y	*Integrated Planning Act 1997*; *Environmental Protection Act 1994*; *Environmental Protection (Noise) Policy 1997*; *Environmental Protection Regulation 1998*; South East Queensland Regional Landscape Strategy	
	Managing development (R; QldSoE03)	Y		
	Community attitudes and actions (R; ANZ-HS11)	Y		
	Life expectancy (C; QldSoE99)	Y		
	Indigenous and non-Indigenous variation in health status (C; QldSoE99)	Y		
	Exceedences of drinking water quality (C; ANZ-HS3)	N		
	Urban socioeconomic inequality (C; AusSoE01)	Y		
	House price:income ratio (C; AusSoE01)	Y		
	Changes in community renewal areas (R; QldSoE03)	Y		
	Proportion of urban land conserved as green space (R; QldSoE99)	Y		
	Urban green space (R; ANZ-HS4)	Y		
THEME: NATURAL AND CULTURAL HERITAGE (Chapter 9)				
Issues	**Indicators**	**Reported**	**Primary responses (legislation and strategies)**	**Links to other themes/issues**
Knowledge of Queensland's heritage	Number of heritage places identified and recorded on Queensland and Commonwealth heritage inventories (C, P; QldSoE99, AusSoE01)	Y	*Queensland Heritage Act 1992*; *Newstead House Trust Act 1939*; *Historic Shipwrecks Act 1976*; *National Trust of Queensland Act 1963*; *Queensland Heritage Regulation 1992*; *Cultural Record (Landscapes Queensland and Queensland Estate) Act 1987*; Ten-year Strategic Partnership Framework for Aboriginal and Torres Strait Islander Peoples; Montreal Process for Sustainable Forest Management	Theme: Biodiversity
	Number, size and distribution of Queensland's protected areas (C; QldSoE03)	Y		
	Number of places in Queensland on the World Heritage List (C; QldSoE03)	Y		
	Distribution of heritage places identified and recorded on Queensland or Commonwealth heritage inventories (C, P: AusSoE01)	Y		
	Number of heritage places reported to and recorded by the EPA per year (C, P; QldSoE03 derived from QldSoE99)	Y		
	Land area surveyed for heritage places (C; QldSoE99)	Y		
	Number of each type of recorded heritage place (C; QldSoE99)	Y		
	Number of heritage places recorded that have been assessed for their heritage significance (C; QldSoE03, QldSoE99 derived from AusSoE01)	Y		
	Number of museums and collecting institutions in Queensland (C; QldSoE99)	Y		
	Range of types of museums in Queensland (C; QldSoE99)	Y		
	Number of items in heritage collections (C; QldSoE99)	Y		
	Proportion of collections accessioned or documented, including proportion catalogued on computer (C; QldSoE03 derived from QldSoE99, AusSoE01)	Y		
	Rate of collection growth in Queensland's collecting institutions (C, P; QldSoE99)	Y		
	Storage space available for collection growth in Queensland's collecting institutions (C, P; QldSoE99)	Y		

Issues	Indicators	Reported	Primary responses (legislation and strategies)	Links to other themes/issues
Assessing the condition of Queensland's heritage	Number of recorded Indigenous heritage places that have been adversely affected by human activity (C, P: QldSoE03 derived from AusSoE01)	Y	*Queensland Heritage Act 1992*; *Newstead House Trust Act 1939*; *Historic Shipwrecks Act 1976*; *National Trust of Queensland Act 1963*; *Queensland Heritage Regulation 1992*; *Cultural Record (Landscapes Queensland and Queensland Estate) Act 1987*; Ten-year Strategic Partnership Framework for Aboriginal and Torres Strait Islander Peoples, National Trust Endangered Places Program	Theme: Biodiversity
	Number of permits issued under cultural heritage legislation	Y		
	Number of places removed from the Queensland Heritage Register (P; QldSoE99)	Y		
	Number of applications for development of heritage registered places under ss 34 and 37 of the Heritage Act (P; QldSoE03 derived from QldSoE99)	Y		
	Number of historical heritage places assessed (by sampling) as being in (a) good, (b) average and (c) poor condition (C, P; AusSoE01)	Y		
	Proportion of natural heritage places with protected area status (C; QldSoE03)	Y		
	Proportion of collections surveyed by trained conservators/ curators (C, P; QldSoE03 derived from AusSoE01, QldSoE99)	Y		
	Proportion of collections requiring conservation subsequently treated (R; AusSoE01)	Y		
	Proportion of collections stored in appropriate environmental conditions (C, P; AusSoE01, QldSoE99)	Y		
	Number and distribution of people who identify as speaking an Indigenous language (C; QldSoE03 derived from AusSoE01)	Y		
	Number of people by age group who identify as speaking an Indigenous language (proportion of total identifying as Indigenous) (C; AusSoE01)	Y		
	Level of documentation for Indigenous languages in Queensland (C, R; QldSoE03 derived from AusSoE01)	Y		
Protecting Queensland's heritage	Funds allocated by government for the protection and conservation of natural heritage (C; QldSoE03)	Y	*Queensland Heritage Act 1992*; *Newstead House Trust Act 1939*; *Historic Shipwrecks Act 1976*; *National Trust of Queensland Act 1963*; *Queensland Heritage Regulation 1992*; *Cultural Record (Landscapes Queensland and Queensland Estate) Act 1987*; Ten-year Strategic Partnership Framework for Aboriginal and Torres Strait Islander Peoples; *Master Plan for Queensland's Parks System*; *State Coastal Management Plan–Queensland's Coastal Policy*	Theme: Biodiversity
	Funds allocated to Queensland Government agencies for the management of protected areas (C; QldSoE03)	Y		
	Proportion of natural heritage places with a management plan (C; QldSoE03)	Y		
	Funding allocated to Queensland Government agencies responsible for the protection and/or promotion of cultural heritage places (R; QldSoE03 derived from AusSoE01)	Y		
	Funds allocated by Queensland Government agencies responsible for the protection and/or promotion of cultural heritage collections (R; QldSoE03 derived from AusSoE01)	Y		
	Funds and associated support provided by Queensland Government agencies to the community and local government for the maintenance, protection, conservation and promotion of cultural heritage places and collections (R; QldSoE03 derived from QldSoE99)	Y		
	Funds and associated support provided by government to small museums (R; QldSoE03 derived from QldSoE99)	Y		
	Number of museums with collection policies (C, R; QldSoE03 derived from QldSoE99)	Y		
	Number of state and local government agencies that have initiated and/or completed cultural heritage studies (R; QldSoE03 derived from QldSoE99)	Y		
	Number of Indigenous people employed by government for the management and protection of Indigenous cultural heritage (R; QldSoE03 derived from AusSoE01)	Y		
	Number and type of Indigenous language programs undertaken in language centres, schools and other institutions (R; AusSoE01)	Y		

Issues	Indicators	Reported	Primary responses (legislation and strategies)	Links to other themes/issues
Community awareness and support	Nature and level of Indigenous community involvement in cultural heritage management (R; QldSoE03 derived from QldSoE99, AusSoE01)	Y	*Queensland Heritage Act 1992*; *Newstead House Trust Act 1939*; *Historic Shipwrecks Act 1976*; *National Trust of Queensland Act 1963*; *Queensland Heritage Regulation 1992*; *Cultural Record (Landscapes Queensland and Queensland Estate) Act 1987*; Ten-year Strategic Partnership Framework for Aboriginal and Torres Strait Islander Peoples	Theme: Biodiversity
	Number and type of heritage places listed by the National Trust of Queensland (per year) (C, R; QldSoE03 derived from QldSoE99)	Y		
	Number of members of community-based cultural heritage organisations (C, R; QldSoE03 derived from AusSoE01)	Y		
	Number of visitors to Indigenous heritage places (P, R; QldSoE03 derived from QldSoE99, AusSoE01)	Y		
	Number of visitors to historical heritage places, including number of dives to historic shipwrecks in protected zones (P, R; QldSoE03 derived from QldSoE99, AusSoE01)	Y		
	Number of visitors to natural heritage places (C; QldSoE03)	Y		
	Number of visitors to collecting institutions in Queensland (P, R; QldSoE03 derived from AusSoE01)	Y		
	Number of heritage management professionals practising in Queensland (R; QldSoE03 derived from AusSoE01)	Y		
	Types of tertiary-level training available to cultural heritage management professionals practising in Queensland (R; QldSoE03 derived from AusSoE01)	Y		
	Number of Indigenous language media programs (C, R; QldSoE03 derived from AusSoE01)	Y		

2 Towards sustainability

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Author

Dr John Cole, Environmental Protection Agency

Reviewer

Alan AtKisson, CEO AtKisson Accelerate Sustainability, USA

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Dr Joe Baker, Chief Scientist, Department of Primary Industries; Ron Apelt, Department of Public Works; Rene Batchelor, Ian Eskdale, Katrina Hergstrom, Dr Laurence Knight, Stacy McLeod, Lynne Turner and Lynn Whitfield, Environmental Protection Agency; and Max Moran and Neil Peach



The sustainability imperative

Energy, materials and water are limited and we have got to learn to live with less. (Dr Joe Baker, DPI, pers. comm.)

The environment is the living system in which all life is nurtured and nourished. Escalating rates of environmental degradation in every major ecosystem on Earth point to the inescapable fact that humankind is not living sustainably.

In making the transition to living sustainably, Queensland faces many of the challenges confronting Australia and other countries. This chapter explores the issue of sustainability in the state context. What does sustainability mean? Why does it matter? What are Queenslanders doing to promote sustainable development? What are the key challenges faced in moving towards a sustainable Queensland? This much is known: in the years ahead Queenslanders will have to move the focus of their attention from dealing with the symptoms of unsustainable development to resolving the causes of environmental decline.

In 2003, the International Year of Freshwater, we were reminded that much more has to be done to understand our environment and reduce our impact on it. Fresh water, Australia's most precious resource, is in serious need of conservation and protection; yet, in the driest of all continents, it continues to be wasted.

This tension between understanding the importance of issues such as water use and people's willingness to undertake the necessary changes in behaviour and lifestyle to deal with them lies at the heart of the challenge in working towards sustainability. As Queensland's population grows, its impacts on the environment will continue to increase. Between 1991 and 2001, the state's population increased by 668 000 to 3 628 946 people; the majority of these people live in urban areas.

Water use is just one of many issues discussed in this report in chapters dealing with atmosphere, land, inland waters, the coastal zone, biodiversity, human settlements and natural and cultural heritage. *State of the Environment Queensland 2003* attempts to provide accurate accounts, based on the best available information, of what resources are consumed in the state's economic and social processes.



Queensland's population is growing. (Photo: L. Knight, EPA)

The main aim is to ensure that decision makers have access to relevant information in formulating policies, determining priorities and devising strategies. The key findings of this report indicate that Queenslanders still have a long way to go to become sustainable. However, while discernible results are difficult to detect and may take many years to become apparent, the integration of environmental, social and economic outcomes is figuring more seriously in the decisions made at all levels of human activity.

Business as usual is no longer an option—for government, the private sector or individual citizens. Our soils, waters, forests and minerals are not inexhaustible. Farms, industries, homes and lifestyles must become more sustainable in every community on our planet. To be sustainable, development must improve economic efficiency, protect and restore ecological systems, and enhance the wellbeing of all peoples. (IISD 2003)



Sustainable water use is critical. (Photo: DNRM)



Unsustainable patterns of development cause environmental degradation. (Photo: DNRM)

The critical themes of sustainability

After two centuries of rises in labor productivity, the liquidation of natural resources at their extraction cost rather than their replacement value, and the exploitation of living systems as if they were free, infinite, and in perpetual renewal, it is people who have become an abundant resource, while nature is becoming disturbingly scarce. (Hawken et al. 1999)

The terms 'sustainability', 'sustain', 'sustainable' and 'sustainable development' mean something different to everyone. Put simply, 'sustainability' means thinking about and protecting the things that matter most—health, family, clean air and water, safe food, personal security, shelter, education, employment and opportunity. All these depend on the goods and services provided by healthy living systems. We need to improve the way we value and do things, and ensure that our values, decisions, institutions and activities are consistent with protecting the things that matter.

The strategic concepts of sustainability are complex and demanding; they raise issues of economic and social transformation, which challenge the way we value and measure progress, capital, wellbeing and growth. The concept of sustainability provides a framework for integrating economic, social and environmental considerations into decision making (figure 2.1). It is important to recognise that economic activity is a function of society and that social and economic activities draw on the resources and life services provided by the natural environment. Further depletion and degradation of our natural systems are unsustainable and limit further economic and social development.

Protecting and investing in nature

All too often people focus only on the things that are valued or priced through market mechanisms. This means that many important factors, such as the air we breathe, are not appropriately or fully valued. Because the full impacts are not spelt out, taxpayer and consumer dollars are often spent on policies, infrastructure and functions that are not optimal for society and that, in many cases, have adverse impacts on the environment.

In posing an alternative, more sustainable way forward, in 1999 the internationally influential book *Natural Capitalism: Creating the Next Industrial Revolution* provided a compelling argument for future economic and social development to be based on fully valued natural systems (Hawken et al. 1999). It proposed four critical strategies for reducing human impacts on the biosphere as well as creating the major economic opportunities of the 21st century:

- significantly reducing our drain on natural resources by radically improving our resource productivity;
- eliminating waste by mimicking nature's closed loop processes;
- moving beyond the current focus on goods to a service-based economy; and
- investing in natural capital for security and stability.



Figure 2.1 *Society and the economy are wholly dependent on the natural ecology of the planet. Ecological considerations are integral to effective social and economic planning. (Photos: EPA)*
Source: ASEC 1996



Sustainability is about people and nature. (Photo: L. Knight, EPA)

People at the centre

Human beings are at the centre of concerns for sustainable development. They are entitled to a healthy and productive life in harmony with nature. (Principle 1 of the Rio Declaration on Environment and Development, UNCED 1992)

While much of the sustainability challenge rests in reversing the almost universal decline of the natural environment, sustainability is as much about people as it is about nature. It means moving beyond notions of balancing environment and economy to integrating the two and accepting that the economy and society are subsystems of the whole and are dependent on nature.

Ensuring a sense of community

Personal initiative, empowerment and collective accountability for the future underpin sustainability. People can think globally and act locally, and beyond the contribution of government, there is much they can do as businesses, groups and individuals. A sustainable community:

- is one whose people enjoy opportunity and amenity, and are proud of their heritage but look forward to the future;
- recognises the interdependence of nature, society and economy in shaping its quality of life. It lives within its physical limits and practises sustainable development;
- is adaptive and capable of change because it is educated; and
- grows stronger with the passage of time.

Segmentation, specialisation and rationalisation are the socioeconomic themes that have characterised the decline of communities everywhere. Across the world, through initiatives as diverse as government eco-efficiency programs, public and private sector infrastructure partnerships, community banking or simple local self-help projects, communities are finding the tenets of sustainability most useful as an organising framework for reviving their fortunes, their amenity and their belief in themselves.

Sustainability and profitability

Sustainable development involves the simultaneous pursuit of economic prosperity, environmental quality and social equity. Companies aiming for sustainability need to perform not against a single, financial bottom line but against this triple bottom line. (Elkington 1998)

A key grouping of some of the biggest and most important companies in international business is taking up the sustainability challenge.

The World Business Council for Sustainable Development (WBCSD) is proving that improved sustainability, performance and profitability are not incompatible. Money-saving steps are the most compelling initial steps on the pathway to sustainability; and for the business sector, this has underpinned the attraction of eco-efficiency—that is, doing more with less. Eco-efficiency saves money and minimises waste and is an essential tenet of improvements in the way we do things. It involves:

- reducing the material intensity of goods and services;
- reducing the energy intensity of goods and services;
- reducing toxic dispersion;
- enhancing material recyclability;
- maximising sustainable use of renewable resources;
- increasing material durability; and
- increasing the service intensity of goods and services.

Besides promoting the benefits of eco-efficiency and innovation, the WBCSD has led the beginnings of a widespread demand for corporate social responsibility, emphasising that:

- the needs of the future must not be sacrificed to the demands of the present;
- the present world system is not sustainable, and people must make changes now to meet their current needs;
- humanity's economic future is linked to the integrity of natural systems;
- people must act to preserve as many options as possible for future generations, since they have the right to determine for themselves their own needs; and
- protecting the environment is impossible unless people improve the economic prospects of the Earth's poorest peoples (WBCSD 2003).



We need to preserve options and resources for future generations. (Photo: L. Knight, EPA)

Partnerships as a vehicle for action

Partnership is the crucial mechanism of sustainability. Laws set basic performance goals and reflect the aspirations of society. While laws demand compliance, they do not, however, provide motivation at the level required to imbue sustainability in the hearts and minds of people. The work of sustainable development needs to be grounded in concepts such as mutual benefit, affirmation of value and belief in the future, and employ arrangements that define and share responsibility.

Each hour, 10 000 people are born on Earth. Each week, the population of the world's cities grows by a million people, largely migrants from rural and regional areas. These socio-demographic realities offer challenges of enormous magnitude, simply in providing the infrastructure to feed and shelter so many new arrivals. The speed at which change is happening and the complexities of the problems facing humanity exceed the capacity of any single sphere of society to effect solutions. An equitable and sustainable world will require the creativity, capacities and collaboration of all sectors, government, business and community.



Creativity is a component of sustainability. (Photo: L. Knight, EPA)

Sustainable development as change

The Brundtland Commission (WCED 1987) asserted that sustainable development 'is not a fixed state of harmony, but rather a process of change in which the exploitation of resources, the direction of investments, the orientation of technological development, and institutional change are made consistent with the future as well as present needs'. Sustainable development involves thinking in the long term, understanding systems, recognising limits, protecting nature, transforming business as usual, practising fairness and embracing creativity (AtKisson 1999). In adopting sustainable development, today's people are compelled to look beyond the here and now, to extend their time horizon 'out two generations', and to consider the connections between 'global carrying capacity and the exponential growth of population, capitalization, resource consumption, and pollution' (Richardson 2003). It all starts with an acceptance of a need for change.

According to Speth (1988), at least six fundamental transitions need to occur within the next few decades at a global and local level before people can even begin to talk about achieving sustainability. These include:

- a demographic transition to a roughly stable world population;
- a technological transition to a minimal environmental impact per person;
- an economic transition to a world in which attempts are made to charge the real costs of goods and services, including environmental costs, so that there are incentives for the world economy to live on nature's income rather than its capital;
- a social transition to a broader sharing of that income;
- an institutional transition to a set of supranational alliances that deliver effective global strategies and solutions; and
- an informational transition to a world in which science, education and global monitoring enable people to understand the nature of the challenges they face.

Other transitional processes that are crucial to embed sustainability at the national, state and community levels include:

- changes in public values and behaviour that emphasise long-term thinking, creativity and fairness;
- better communication of science and empirical data to improve the community's understanding of and engagement with the world as an interdependent system;
- improved transparency in the democratic processes to promote broader public participation in discussions about the future;
- setting goals and formulating public and private sector strategies that facilitate sustainable development and new ways of doing business;
- development of measurement processes and performance indicators to monitor developments and evaluate progress; and
- commitment to policy adjustment in support of sustainable development.



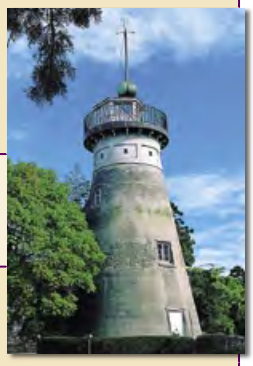
Reconnecting with nature at Carnarvon Gorge. (Photo: Tourism Queensland)

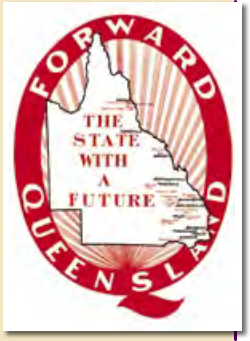
Queensland's journey towards sustainability

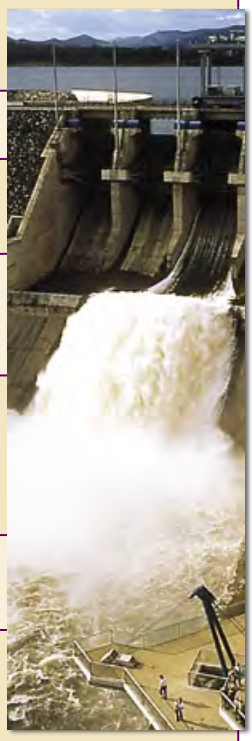
Looking back

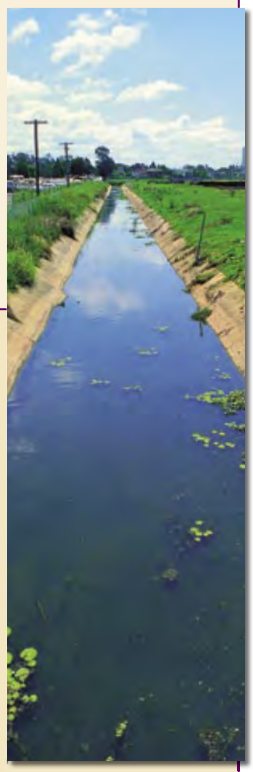
Queensland's prosperity has always been dependent on the state's natural resources. Table 2.1 illustrates the historical context of sustainability in Queensland and some of the key drivers internationally and nationally.

Table 2.1 The historical context of sustainability in Queensland

International and national milestones	Timeline	Queensland milestones
European settlement of Australia started	1788	
Red cedar samples dispatched to London	1791	
Merino sheep established in Australia	1797	
	1824	European settlement at Moreton Bay started
Gold discovery near Bathurst set off the first Australian gold rush	1851	
Population of Australian reached 1 000 000	1858	
Wild rabbits released in Victoria	1859	
George Goyder mapped the line of reliable rainfall in South Australia	1864	First sugar produced from Queensland cane
	1867	Gold mining started at Gympie
	1870	First timber reserves gazetted
	1874	Red cedar logging began in the wet tropics
	1877	Red cedar in Daintree and Mossman valleys totally cut out
First bore tapping into the Great Artesian Basin (Bourke, NSW)	1878	
First Australian national park, Royal National Park, established in NSW	1879	
Karl Benz produced the world's first motor car	1886	Construction of the rabbit-proof fence commenced

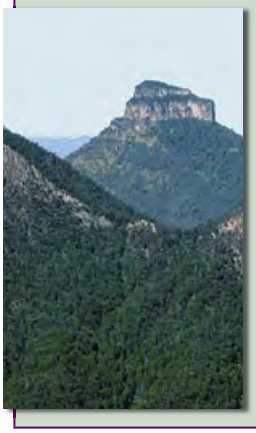
International and national milestones	Timeline	Queensland milestones
	1900	Forestry Branch established in the Department of Public Lands
	1908	First national parks established at Mt Tamborine and the Bunya Mountains
Griffith Taylor predicted that the population of Australia would not exceed 20 million by 2000 AD	1911	
	1927	Last confirmed sighting of a paradise parrot
	1931	Mining began at Mount Isa
	1935	Cane toads introduced to control cane beetles
Last recorded thylacine died in Hobart Zoo	1936	
Simon Kuznets presented a set of national accounts (GDP) to the US Congress	1937	
	1938	Population of Queensland reached 1 000 000 John Bradfield proposed a scheme to turn Queensland's rivers inland 

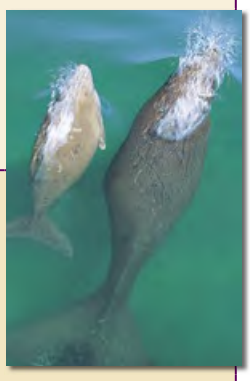
International and national milestones	Timeline	Queensland milestones
United Nations formed United Nations Educational, Scientific and Cultural Organization formed Commonwealth Bureau of Census and Statistics produced the first official set of national accounts	1945	
Aldo Leopold developed the Land Ethic International Union for the Protection of Nature established	1948	
Commencement of the Snowy River Scheme	1949	
Great London Smog killed thousands	1952	
Widespread mercury poisoning at Minamata, Japan	1956	
Significant radiation release following a fire at the Windscale nuclear reactor, UK	1957	
First cod war between Iceland and the United Kingdom Commencement of the Ord River Scheme	1958	
Population of Australia reached 10 000 000	1959	
World Wildlife Fund established	1961	
Rachel Carson published *Silent Spring*[a] 	1962	First observed crown-of-thorns starfish outbreak on the Great Barrier Reef Whaling ceased at Tangalooma after humpback whale numbers crashed Wildlife Preservation Society of Queensland formed
	1963	Clean Air Act
Australian Conservation Foundation established	1964	

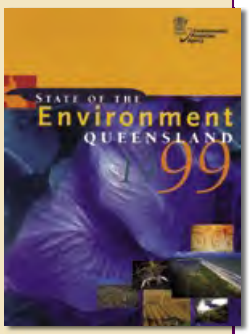
International and national milestones	Timeline	Queensland milestones
Kenneth Boulding introduced 'spaceship earth' metaphor Australian Marine Conservation Society formed	1965	
Wittenoom asbestos mine closed	1966	Queensland Air Pollution Control Council created
First moon walk	1969	Queensland Conservation Council established
US Environmental Protection Agency established	1970	
Inaugural Earth Day First Greenpeace action Friends of the Earth formed Ramsar Convention on Wetlands Builders' Labourers Foundation imposed a green ban to protect open space in Sydney	1971	Clean Waters Act 
United Nations Conference on the Human Environment, Stockholm; United Nations Environment Programme established Convention Concerning the Protection of the World Cultural and Natural Heritage (World Heritage Convention) The Club of Rome published *The Limits to Growth*[b] James Lovelock introduced the Gaia Hypothesis	1972	Queensland Water Quality Council created
Convention on International Trade in Endangered Species First oil crisis Lake Pedder flooded Ernst Schumacher published *Small Is Beautiful*[c]	1973	

International and national milestones	Timeline	Queensland milestones
	1974	Queensland population reached 2 000 000 Rainforest Conservation Society formed
Australian Heritage Commission established	1975	Queensland National Parks and Wildlife Service formed Griffith University established the first school of environmental studies in Australia
Chemical facility explosion at Seveso, Italy, caused widespread exposure to dioxins Wilderness Society formed	1976	
Herman Daly published *Steady-State Economics*[d] Amory Lovins published *Soft Energy Paths*[e]	1977	Fraser Island placed on the Register of the National Estate
Second oil crisis Love Canal (USA) became infamous as a contaminated site Commonwealth entered into joint management arrangement with Traditional Owners for the management of Kakadu National Park	1978	Queensland Noise Abatement Authority created Protected area estate covered 1% of Queensland land mass 
Bonn Convention on Migratory Species Three Mile Island nuclear accident	1979	
United Nations established the World Commission on Environment and Development (WCED) USA established the Superfund to clean up contaminated sites	1980	
	1981	Great Barrier Reef received World Heritage listing
International Whaling Commission decided to cease commercial whaling by 1986	1982	Marine Parks Act

International and national milestones	Timeline	Queensland milestones
Commonwealth used external affairs power to prevent the damming of the Franklin River	1983	
Toxic gas leak from Union Carbide plant in Bhopal, India, killed thousands of people Commonwealth Government developed the 'three mines policy' for uranium mining	1984	Bloomfield track bulldozed through Daintree National Park
Vienna Convention for the Protection of the Ozone Layer	1985	Protected area estate covered 2% of Queensland land mass
Unleaded petrol made compulsory for new motor vehicles in Australia Chernobyl nuclear accident Emergency Planning and Community Right-to-Know Act (USA)	1986	Kingston residents complained about toxic waste seeping through their properties
WCED published *Our Common Future*[f] (widely known as the 'Brundtland Report')	1987	Queensland Department of Environment, Conservation and Tourism formed
	1988	Wet Tropics received World Heritage listing
Exxon Valdez oil spill in Alaska Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and Their Disposal Herman Daly and John Cobb presented the Index of Sustainable Economic Welfare as an alternative to GDP Resource Assessment Commission established	1989	
The Great Artesian Basin Bore Rehabilitation Program began	1990	Woody vegetation cleared at an average rate of 450 000 ha per year

International and national milestones	Timeline	Queensland milestones
1000 km stretch of the Barwon and Darling rivers affected by the largest toxic algal bloom in history	1991	Contaminated Land Act
Australian National Strategy for Ecologically Sustainable Development endorsed by three levels of government Intergovernmental Agreement on the Environment (Australia) National Environment Protection Council established High Court of Australia recognised native title (Mabo ruling) United Nations Conference on Environment and Development (Rio Earth Summit): • Framework Convention on Climate Change • Convention on Biological Diversity • the Rio Declaration • the Forest Principles • Agenda 21 United Nations Commission for Sustainable Development established Newfoundland cod fishery collapsed	1992	State Government endorsed National Strategy for Ecologically Sustainable Development Queensland signed the Intergovernmental Agreement on the Environment Nature Conservation Act Queensland population reached 3 000 000 Fraser Island received World Heritage Listing
	1993	Queensland Wet Tropics World Heritage Protection and Management Act Protected area estate covered 3% of Queensland land mass

International and national milestones	Timeline	Queensland milestones
	1994	Environmental Protection Act Central Eastern Rainforests Reserves World Heritage Area extended to include Queensland's border ranges Fossil Mammal Sites World Heritage Area (Riversleigh) received World Heritage listing
World Business Council for Sustainable Development established to provide business response to sustainable development issues Redefining Progress (Washington DC) presented the Genuine Progress Indicator as an alternative to GDP	1995	Coastal Protection and Management Act Papaya fruit fly eradication scheme began in north Queensland Great Barrier Reef Marine Park Act
High Court ruled native title and pastoral title can coexist (Wik case)	1996	Cape York Land-Use Agreement Queensland signed the Murray–Darling Basin Agreement
Five-year review of the Earth Summit by UN General Assembly John Elkington published *Cannibals with Forks*[g] and introduced the triple bottom line concept von Weizacker et al. published *Factor Four: Doubling Wealth, Halving Resource Use*[h] National Land and Water Resources Audit began	1997	Environmental Protection Policies for Water, Air and Noise Integrated Planning Act Dugong Protection Areas established 
Global coral reef bleaching International Year of the Ocean Rotterdam Convention on the Prior Informed Consent Procedure for Certain Hazardous Chemicals and Pesticides in International Trade	1998	Protected area estate covered 4% of Queensland land mass

International and national milestones	Timeline	Queensland milestones
Commonwealth Environment Protection and Biodiversity Conservation Act	1999	Environmental Protection Agency (EPA) established Queensland's inaugural state of the environment report South East Queensland Regional Forest Agreement signed Vegetation Management Act 
International Year for the Culture of Peace Earth Charter launched Council of Australian Governments endorsed the National Action Plan for Salinity and Water Quality	2000	Environmental Protection Policy for Waste Management Water Act Queensland, South Australia and the Commonwealth signed the Lake Eyre Basin Intergovernmental Agreement Land clearing peaked at 758 000 ha per year
Stockholm Convention on Persistent Organic Pollutants International Year of Volunteers Commonwealth State of the Environment Report	2001	Fire ants discovered in south-east Queensland Asian green mussel discovered in Cairns harbour
International Year of Mountains International Year of Ecotourism Oil tanker *Prestige* split in half off the Spanish coast World Summit on Sustainable Development (Johannesburg) to build on the achievements of UNCED and deal with remaining goals Foran and Poldy published *Future Dilemmas: Options to 2050 for Australia's Population, Technology, Resources and Environment*[i]	2002	EPA developed the Business Sustainability Roadmap for the Environment Protection and Heritage Council 
International Year of Freshwater Mouth of the Murray River virtually closed Commissioner for Environmental Sustainability established in Victoria Population of Australia reached 20 000 000	2003	Queensland and New South Wales signed an intergovernmental agreement to protect the Paroo River Queensland's second state of the environment report prepared

[a]Carson 1962; [b]Meadows et al. 1972; [c]Schumacher 1973; [d]Daly 1977; [e]Lovins 1977; [f]WCED 1987; [g]Elkington 1998; [h]von Weizacker et al. 1977; [i]Foran and Poldy 2002

Note: The milestones included in the timeline are provided as a guide only. Many other issues and events have not been included.

Sustainability in Australian public policy

In 1992, the Council of Australian Governments agreed that ecologically sustainable development (ESD) is 'development which aims to meet the needs of Australians today, while conserving our ecosystems for the benefit of future generations' (Commonwealth of Australia 1992). This built on the international definition from the World Commission on Environment and Development, which defined ESD as 'development that meets the needs of the present without compromising the ability of future generations to meet their own needs' (WCED 1987).

There are many difficulties in expecting such a general concept as ESD to be clearly understood or to mean exactly the same thing to all people when it covers such diverse areas of activity, yet the term is used universally and has application in international, national and local settings. The importance of how we go about working towards sustainability, as well as what we do, is reflected in the objectives and principles of the National Strategy for ESD, signed by all Australia's governments in December 1992.

The core objectives of the National Strategy for ESD are:

- to ensure a path of economic wellbeing that safeguards the welfare of future generations, often referred to as 'intergenerational equity';
- to enhance individual and community wellbeing within and between generations, often referred to as 'intragenerational equity'; and
- to conserve and protect biological diversity and essential ecological processes and life-support systems.

The National Strategy for ESD provides the following principles for decision making:

- integrate short- and long-term economic, environmental, social and equity considerations into decision making processes;
- deal cautiously with risk and irreversibility (the precautionary principle);
- recognise and consider the global dimension;
- develop a strong, growing and diversified economy to enhance the capacity for environmental protection;
- maintain and enhance international competitiveness;
- adopt cost-effective and flexible policy instruments; and
- involve the community in decision making (Commonwealth of Australia 1992).

Recent surveys of the corporate sector report high levels of awareness of and willingness to commit to sustainability but low levels of practical understanding and implementation of sustainability practices (Ernst and Young 2002; Pricewaterhouse Coopers 2002). Similarly, the Productivity Commission (1999) reviewed Commonwealth Government practices and found a lack of clarity as to what ecologically sustainable development means for government policy, and ambiguity about how sustainability principles and strategies apply to government activities. It is likely that the same finding would apply to state and local governments across Australia, including Queensland.



Sustainability requires changes in attitudes and behaviour. (Photo: EPA)

Sustainability in Queensland public policy

The Queensland Government has made an explicit commitment to sustainable development through its legislation and its planning processes. It recognises that a 'healthy and sustainable environment is essential to our future'. Since 1994 sustainable development principles have been included in a range of legislative instruments and government business practices. (See *Implementing the Legislation* for more detail.) The objectives and principles of the National Strategy for ESD are reflected in Queensland public policy through the following guiding principles (DPC 2002):

- integrated and long-term decision making—integrating long- and short-term environmental, economic and social considerations into decision making;
- intergenerational equity—ensuring that the health, diversity and productivity of the environment are maintained or enhanced for the benefit of future generations;
- intragenerational equity—equitable sharing of resources and opportunity among present generations;
- the precautionary principle—ensuring that where there are threats of serious or irreversible environmental damage, lack of full scientific certainty is not used as a reason for postponing measures to prevent environmental degradation;
- conservation of biological diversity and ecological integrity—protecting the variety of all life forms, their genetic diversity and the ecosystems of which they form a part, in recognition of the various services they provide to humans as well as their intrinsic values; and
- internalising environmental costs—ensuring that the true life cycle costs (costs incurred from the production of inputs through to waste disposal) of protecting and restoring environmental damage are reflected in the price of a product or service.

By articulating a commitment to the guiding principles of sustainability, Queensland has taken the first steps in the complex and challenging transition to a sustainable society. The *Environmental Protection Act 1994* (EP Act) was a significant milestone for Queensland on its journey towards sustainability. The object of the Act is to protect Queensland's environment while allowing for development that improves the total quality of life, both now and in the future, in a way that maintains the ecological processes on which life depends ('ecologically sustainable development').

The definition of 'environment' in the EP Act reflects the principles of sustainability illustrated in figure 2.1:

' **"Environment"** includes—

(a) ecosystems and their constituent parts, including people and communities; and

(b) all natural and physical resources; and

(c) the qualities and characteristics of locations, places and areas, however large or small, that contribute to their biological diversity and integrity, intrinsic or attributed scientific value or interest, amenity, harmony and sense of community; and

(d) the social, economic, aesthetic and cultural conditions that affect, or are affected by, things mentioned in paragraphs (a) to (c).'

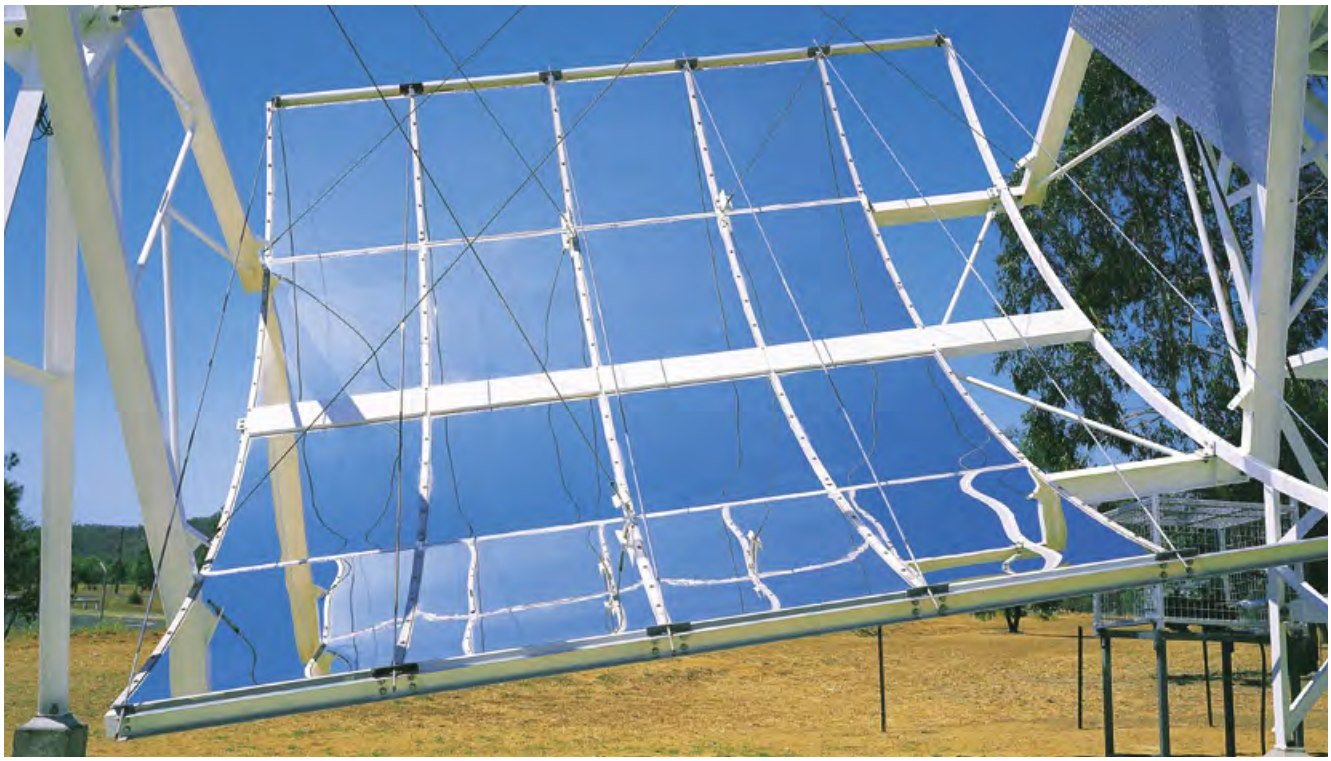
The Charter of Social and Fiscal Responsibility (Qld Treasury 2001) ensures that the contribution of the government is not assessed purely against economic and financial criteria, but that the social and environmental consequences are also considered. It identifies five government priorities:

- more jobs for Queensland;
- safer and more supportive communities;
- community engagement and a better quality of life;
- valuing the environment; and
- building Queensland's regions.

The Queensland Government is committed to protecting the state's natural and cultural heritage for current and future generations, and managing natural resources development in an ecologically sustainable way. This commitment to the environment and sustainability underpins Queensland's journey towards sustainability. (See the 'Response' sections within the issues discussed in this report and the case studies later in this chapter for other key activities.)



Sustainability requires meeting the needs of the current generation without compromising the wellbeing of future generations. (Photo: EPA)



Solar prisms exemplify technological advances towards increasing the use of renewable energy sources. (Photo: EPA)

Undeniably, there are real costs (social, economic and ecological) associated with implementing sustainable development. However, the cost of doing nothing or falling short of sustainable development will be far greater and will compound for future generations of Queenslanders. The environmental issues discussed in other chapters of this report are symptoms of unsustainable development. This chapter discusses some of the warning signs that are telling us that we need to change the way we are doing things.

Progress towards the responsible use of natural capital and primary resources

For Queensland to be sustainable, we shall have to use our renewable resources at a rate which enables them to be replenished, and progressively we shall have to replace non-renewable resources used in products and processes with renewable resources. At present, Queensland's consumption of resources is generally increasing, due largely to population and economic growth, but also because of increased per capita consumption of products and services and greater energy intensity in our lifestyle, in developments such as home air conditioning.

The thematic chapters within this report uncover significant findings:

- significant soil structure decline occurs on approximately 450 000 ha of cropping land. This has implications in terms of a decrease in resource productivity and the increased working of more marginal land. Significant areas of cultivated land are experiencing declining soil fertility, particularly in the Darling Downs and Burnett catchments. In general, nutrients are being depleted from most cropping and grazing regions through leaching, soil runoff and removal of produce (Qld Treasury 2002, p. 110);
- in Queensland the use of surface water and groundwater increased by 97% between 1983–84 and 1996–97. The Great Artesian Basin is the most significant groundwater resource in Queensland. In July 2002, 533 artesian bores were uncontrolled and the length of remaining bore drains totalled 15 700 km. The amount of water wasted from the bores and drains is estimated to be 390 000 ML/year. In one of the driest continents of the world and the driest state in Australia, this waste is clearly not sustainable. Water use is increasing, due primarily to population growth and economic development. Because of the seasonal and unreliable nature of Queensland's rainfall, agricultural and domestic activities rely heavily on surface water storages, which provide approximately 64% of the state's total water consumption (Qld Treasury 2002, p. 114);
- harvesting of wild fish and crustacean stocks continues to increase despite increased production from commercial aquaculture. Queensland's commercial fisheries are the third largest in value in Australia and the eighth most valuable primary producer for the state. Queensland's commercial fisheries have two sectors: the harvest sector and aquaculture. The harvest sector has a gross value production (GVP) of about $295 million and the aquaculture sector has a GVP of about $55 million (Williams 2002, p. 1); and
- consumption of electricity is growing strongly in Queensland, driven by robust economic and population growth. Based on current trends, annual electricity demand is projected to grow to around 55 000 gigawatt hours (GWh) by 2011–12. Currently, Queensland's electricity generation sector is dominated by non-renewable coal-fired plant, although increasing quantities of gas will be used in the future (Qld Treasury 2002, p. 109).



Queenslanders are still sending large volumes of waste to landfill. (Photo: EPA)

Progress towards a clean environment through protection of air, water and land quality

Sustainable development implicitly requires that human impacts on 'the commons'—air, land and water—are managed to ensure that the environmental quality is maintained and that emission and discharge of wastes and pollutants do not degrade the environment or compromise its carrying capacity.

Findings from the thematic chapters in this report indicate that further work is required to ensure that Queensland's air, land and water resources are used sustainably. Various issues are discussed below:

- Soils in parts of coastal, south-west and northern Queensland are naturally saline, although land management practices, particularly clearing of deep-rooted vegetation and cropping practices, have the potential to lead to dryland or irrigation salinity. A small area of the state (approximately 48 000 ha) is significantly affected by salinity. The recent declaration of an increase in the area affected by salinity is due mainly to a greater understanding of the processes and practices that result in salinity and recognition of salinity in the field.
- Queensland's greenhouse gas emissions (including those resulting from land clearing) were approximately 151.9 million tonnes of carbon dioxide equivalent in 1999. This equates to approximately 29% of Australia's total emissions, the second highest emissions rate behind New South Wales and the Australian Capital Territory combined (Qld Treasury 2002, p. 108).
- Pressures on air quality in Gladstone and Mount Isa are more likely to be managed by technological advances than by legislative responses.
- Participation in household recycling has increased in Australia since 1992, from 85% (at least one item of household waste recycled) to 97% in 2000 (practising at least some recycling). The per capita disposal of domestic waste still remains high, at approximately 400 kg/year (ABS 2003, p. 425).
- Australia's history of agricultural practices has resulted in an accelerated leakage of nutrients and sediments from Australian landscapes. In Queensland, hill-slope erosion is the dominant process. Most nutrients and sediment entering the state's waterways are deposited on floodplains. Of the total phosphorus entering waterways, 60% is deposited on the floodplains, 13% is stored in reservoirs, and 27% reaches the coast. Of the total nitrogen entering the river systems, 41% is deposited on floodplains, 9% is stored in reservoirs, and 39% reaches the coast. The remaining 11% is converted to nitrogen gas and discharged to the atmosphere (ABS 2003, p. 453). Discharges into river systems are now being controlled by the implementation of improved land management practices that are being adopted through community extension such as integrated catchment management and Landcare.
- Tourism and increased visitor numbers are placing increasing pressure on Queensland's cultural heritage.

Progress in maintaining biodiversity

The maintenance of biodiversity is fundamental to ensuring a sustainable Queensland—not only in terms of the maintenance of existing biodiversity, but also in the enhancement of the environment through rehabilitating degraded environments and making useful habitats.

The findings of some of the thematic chapters in this report indicate that:

- clearing of native vegetation is now occurring on land traditionally regarded as less productive. This places further pressure on land that is more vulnerable to degradation. Approximately 32 million hectares have been cleared of native remnant vegetation (that is, vegetation approximating original vegetation). This equates to 19% of the state's total land area, although most clearing has occurred in the more easterly parts of the state. It is estimated that land was cleared of woody vegetation in Queensland at a rate of 289 000 ha/year between 1991 and 1995, a significant reduction on previous years. However, between 1997 and 1999 this increased to an average rate of 425 000 ha/year. Approximately 86% of the total land cleared of woody vegetation was for pasture establishment (Qld Treasury 2002, p. 119);
- Queensland is Australia's most naturally diverse state. It has 13 terrestrial and 14 marine bioregions, which support over 1000 ecosystem types, habitat for approximately 65% of Australia's known frog, reptile, bird and mammal species, and 47% of its plant species. Biodiversity is being conserved, as indicated by an increase in the representation conserved in protected areas. Queensland has identified 1160 unique regional ecosystems. Of these, 108 are classified as endangered, 409 as of concern, and the remaining 643 as not of concern;
- the protected area estate increased from approximately 3.4 million ha in 1985 (2% of the state) to about 7.5 million ha (4.3%) in 2001. The protection of regional ecosystem diversity represented within Queensland conservation areas increased from 44% in 1985 to 70% in 2001; and
- Queensland has 1896 fauna species, of which 75 are vulnerable, 47 are endangered and 6 are presumed extinct. As of 2002, 10 229 plant species have been identified. Of these, 277 are vulnerable, 149 are endangered and 29 are presumed extinct (Qld Treasury 2002, p. 12).



High rates of land clearing have the potential to cause a wide range of environmental problems. (Photo: DNRM)

Glimpses of the future

In the practices of innovative Queensland communities, businesses and government agencies, endeavouring to become sustainable is a present reality; some of the best examples reach international best practice benchmarks. Sustainable development requires new ways of thinking, innovation and adjustment, but it is well within our collective capacity. The case studies below flag the start that has been made and point to the benefits flowing from integrated environmental, economic and social decision making.

Community development

Case study: Sustainable Gladstone

The Gladstone Region Sustainability Group is tackling sustainability issues in the diverse and rapidly developing area around the city of Gladstone. With representation from community groups, local and state government agencies, industry sectors and educational institutions, this group is actively working to secure a sustainable future for the region.



The Sustainable Gladstone project brought together community, industry and government agencies to develop an action plan for the region. (Photo: EPA)

In 2001, a comprehensive sustainability strategy and an action plan were developed for the region, with indicators to measure progress towards sustainability. As a follow-up to the first sustainability report published (GRSG 2001), a second report is now being prepared to document progress.

The Gladstone community is pursuing its sustainability agenda for the region, as demonstrated by initiatives such as the Gladstone City Council and Queensland Alumina Effluent Reuse Scheme. Under this scheme, secondary treated effluent from the Gladstone City Council's treatment plant is used by Queensland Alumina in the final wash process of alumina production.

This collaboration between council and industry has reduced demand for water by some 6.5 ML/day and stopped effluent discharge into the Calliope River. Annual nutrient loadings in coastal waterways have been reduced by some 14.5 tonnes of total phosphorus and 49.9 tonnes of total nitrogen and the need to upgrade the sewage treatment works has been avoided, saving an estimated $3.5 million on capital works.

Education

Case study: Griffith University EcoCentre

Sustainable building design, as demonstrated by the Griffith University EcoCentre, involves a total life cycle approach, taking into account the environmental impacts that can occur during the construction, daily operations and eventual demolition of a building.

The environmental management plan has ensured best practice standards of work to minimise the impact of the building on the site as well as minimising its resource use.

The construction and operation of the centre follow 'eco-design' principles, featuring solar energy, ambient ventilation and lighting, rammed-earth walls for temperature regulation, rainwater collection and wet composting toilets. All reflect domestic-scale environmental technologies that can be used in the family home.

A photovoltaic system on the roof provides around 7 MWh of electricity annually, saving some $1000 and around seven tonnes of greenhouse gas. A real-time record of the power being generated is displayed on a computer in the centre, providing a valuable learning resource.

The Griffith University EcoCentre provides teaching, exhibition and conference facilities for educational, business and community groups. It enjoys strong support from both government and industry as a multi-functional environmental education centre and a showcase for sustainable building design.



Griffith University's EcoCentre is an excellent example of eco-design in practice. (Photo: EPA)

Case study: Solar schools

The EPA is installing solar power systems in Queensland state schools. The systems deliver immediate benefits to the schools, reducing costs while supplementing electricity supply, as well as providing a long-term showcase to educate the community and tomorrow's leaders about the value and accessibility of renewable energy alternatives.

Photovoltaic modules installed on school roofs convert sunlight into electricity in a way that is clean, non-polluting and renewable, producing neither gaseous emissions nor noise. Unlike traditional electricity production, which uses fossil fuels, solar panels can be installed on existing structures and, because they have no moving parts, require very little maintenance. The power generated by the solar panels reduces the schools' requirement for electricity from the grid and saves each school approximately $500 a year, while also reducing greenhouse gas emissions by 3.6 tonnes a year.



The EPA is installing solar power systems in Queensland state schools. (Photo: EPA)

Aspley Special School, one of the 17 schools participating in the pilot program, installed a 2-kilowatt photovoltaic (solar power) system that is providing 12.5% of the school's power. The real-world operating system and live data provide learning opportunities for the local community and students.

A further 40 urban schools will have solar power systems installed during 2003–04, while 50 remote schools will receive installations under the Solar Schools Goes Bush program during the next five years.

Housing and construction

Case study: Sustainable commercial high-rise buildings



The William Buck Centre during its construction phase (Photo: EPA)

Commercial buildings are major consumers of energy. It has been estimated that the energy used to heat, cool, light and ventilate Australian commercial buildings in 1999 produced 35.1 million tonnes of greenhouse gas emissions, or 6.7% of Australia's total greenhouse gas emissions.

When Forrester Kurts Properties was planning the William Buck Centre, a 21-storey high-rise office development in Brisbane's central business district, the EPA worked with the designers to incorporate eco-efficiency and sustainability principles into both construction and operation of the building. The result is a building that set a new benchmark for cost-effective energy and water service delivery in commercial high-rise buildings in Australia.

The William Buck Centre incorporates an innovative solar power system including 60 kW of photovoltaic panels built into the roof, shading devices and a main atrium. Energy-efficient features include movement and light-level sensors and super-efficient lighting. Water-efficient devices include low-flow shower roses, dual-flush toilets, movement-detector urinals, flow limiters on taps, solar hot water collectors and super-efficient domestic water supply pumps with variable speed drives.

In this case, cost savings and environmental benefits have gone hand in hand. An initial capital investment of $740 000 has resulted in annual savings of 1000 MWh of electricity, 1005 tonnes of greenhouse gas emissions, 6 500 000 litres of water and $171 000 in operational costs.

Case study: Sustainable design in the tropics

A new Cairns building, William McCormack Place, is the first building in Queensland to receive a five-star energy rating. It provides an excellent demonstration of how eco-efficiency can be achieved without compromising either quality or commercial viability.

The EPA worked with the Department of Public Works and the design team, Brisbane's Cox Rayner Architects and Cairns-based CA Architects, to maximise the energy, water and resource efficiency of the building's design and operation.

Design, materials and service provision selections were made on the basis of energy efficiency and life cycle costs. Particular attention was paid to the design and operation of the air-conditioning and electrical systems to deliver maximum energy efficiency while being highly flexible and simple. The building is effectively sealed to minimise leakage of conditioned air to improve efficiency of the system, and this equates to savings of about 360 tonnes of greenhouse gases a year.

The current occupants of the building were surveyed in previous premises and again one year after moving to William McCormack Place. Initial data show that occupant satisfaction with the working environment improved substantially following the move.



William McCormack Place has a five-star energy rating. (Photo: DPW)

Industry and technology

Case study: Sweet snappy solutions



Mulgrave Central Mill, Cairns Crocodile Farm and the environment are all winners. (Photo: EPA)

Cairns Crocodile Farm produces meat and leather products for the export market. Young crocodiles are purchased from Indigenous communities and raised in pens, fed primarily on by-products from poultry processing. To maximise survival and growth rates of juveniles, Cairns Crocodile Farm must ensure that water in the pens is warmed in winter.

When the crocodile farm needed to expand its facility, the EPA supported it in seeking an alternative to simply increasing its boiler capacity.

The sugar-refining process at Mulgrave Central Mill, just 10 km away, produces large quantities of hot water that must be cooled before being discharged into the Mulgrave River. The farm managers negotiated with the mill to pipe the warm wastewater downhill to the crocodile pens, where it now cools naturally, then passes through the farm's wetlands before being discharged into Trinity Inlet.

This partnering solution provided a new way of solving problems that had multiple benefits. Cairns Crocodile Farm has lower fuel and pumping costs, faster-growing crocodiles and increased income; the poultry processor has a better market for its by-products; and Mulgrave Central Mill can sell its warm water and reduce cooling costs. There is environmental benefit from reduced water harvesting and community benefit from the generation of more jobs and income.

Case study: Sustainable yarns

Northstate Carpet Mills on the Gold Coast is a specialist manufacturer of commercial synthetic carpets. By reducing potential waste at the source, finding new markets and reusing or recycling waste materials, the company has reduced its environmental impact and gained impressive business benefits.

The company imports carpet yarns that were formerly packaged in strapped cardboard cartons, generating 63 000 kg of waste cardboard and 420 kg of strapping each year. The yarns are now delivered in recyclable plastic pallet wrap, substantially reducing waste and saving 740 trees and $82 000 annually.

Carpet offcuts of 2200 kg a year were going to landfill, but Northstate has found new business opportunities and customers for this material. Stocks of discontinued yarn amounted to 80 000 kg, but markets have already been developed for 60 000 kg of these offcuts.

Some 300 cubic metres of what was previously waste and costly to dispose of has now been diverted from landfill and converted to saleable resources generating additional income. Weed matting, bedding and carpet underlay are just some of the products from this new resource.

Northstate is looking to further improve its performance by selling yarn tubes back to the manufacturers and expanding reuse and recycling opportunities.

Northstate Carpet Mills has substantially reduced its packaging waste. (Photo: EPA)



Local government

Case study: Bulloo Shire

Since 1891, when Bulloo Shire Council began drilling an artesian bore, the council and the town of Thargomindah have worked together to provide residents with a reliable source of renewable energy. When the bore was struck, it became the source of energy for Australia's first hydro-electric scheme.

In May 2002 the original hydro scheme was recommissioned to commemorate the Year of the Outback and two state-of-the-art renewable energy schemes were implemented.

With the introduction of a new water supply distribution system, Thargomindah ratepayers need to heat their water for the first time in history. Stand-alone solar arrays were installed for the town's swimming pool and council chambers, and more than 100 solar heat-pump hot-water systems were installed to supply every Thargomindah home and business.



Thargomindah residents have capitalised on their artesian resources. (Photo: EPA)

Apart from the energy efficiency and cost-saving benefits for residents, the heat-pump systems require minimal maintenance and are not subject to breakdowns caused by the high calcium content of the local bore water. Calcification on the element is common with other hot-water systems, but in a heat-pump system the element does not come into contact with the water.

Planning and transport

Case study: Sleek trains reduce greenhouse gases

QR (Queensland Rail), Australia's largest rail network, has substantially reduced its greenhouse gas emissions. Three years into its five-year plan to reduce emissions, QR has already reduced greenhouse gas emissions by 329 000 tonnes. This is 15% better than the original goal for the period, and represents 69% of the total five-year savings target.

QR provides urban and long-distance passenger services as well as freight trains carrying export coal, minerals, containers, industrial and primary industry products, and general freight. As about 70% of QR's greenhouse gas emissions is generated from electricity and diesel fuel combustion during train operations, QR has focused on improving the efficiency of these operations. Last financial year, QR carried more than 153 million tonnes of freight and almost 47 million passengers.



Queensland Rail uses locomotive simulators to train its drivers in fuel-efficient driving. (Photo: EPA)

QR has achieved greenhouse reductions by better using the capacity of assets that were previously considered surplus, and by making significant gains through:

- introduction of new and more energy-efficient locomotives and more efficient wagons for coal and other general freight goods;
- increased use of containers for general freight;
- new and more energy-efficient trains on the Brisbane CityTrain network;
- upgraded tracks, resulting in more efficient trains and operations;
- better train scheduling and electronic control systems to reduce transit times and delays; and
- driver training in the dynamics and smooth running of trains to maximise fuel efficiencies and minimise maintenance costs.

Case study: SmartWheel technology

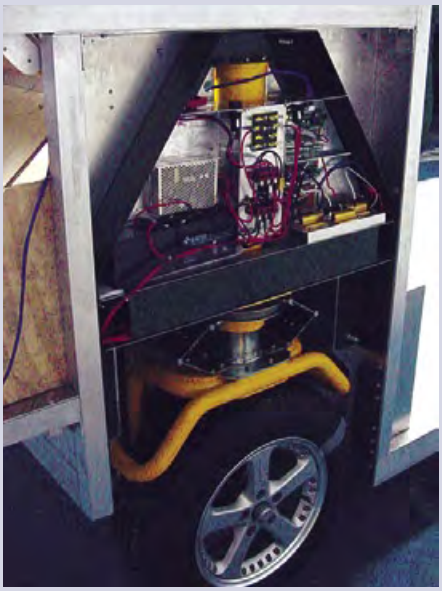
Eze Corp Pty Ltd has developed a 'smart wheel' that offers unprecedented mobility and traction, while reusing energy that would normally be lost during braking.

Each SmartWheel is a self-contained unit, similar to the nose wheel of an aircraft, which offers independent steering and propulsion, allowing vehicles to make very tight turns in confined spaces and even move sideways in 'crab-mode'.

The SmartWheel technology could maximise the potential advantages of both electric and fuel-cell vehicles. It is ideally suited to recover energy during braking or downhill travel, with the drive motor in each wheel charging batteries or supercapacitors.

In rough terrain, the SmartWheel vehicle is expected to outperform conventional four-wheel-drive technology because each wheel is monitored by a computer that instantly adjusts the torque to prevent the wheels from slipping.

Through the Queensland Sustainable Energy Innovation Fund (QSEIF), Eze Corp has been able to develop the SmartWheel, with its sophisticated computer control software, and build a prototype vehicle. The Eze Corp technology has market potential for vehicles such as eco-friendly resort vehicles and zero-pollution inner-city buses, as well as a range of commercial and industrial applications.



The SmartWheel offers independent steering and propulsion, and can recover energy during braking. (Photo: EPA)

Tourism

Case study: Dockside Apartment Hotel



Dockside Apartment Hotel at Kangaroo Point on the Brisbane River is just minutes from the central business district. Its resort-style setting includes landscaped gardens, water features, a town square and private marinas.

Through good environmental management, with attention to regular maintenance and the adoption of technologies such as water flow regulators, the hotel's operating costs have been minimised. However, with an annual energy bill of approximately $335 000, the operators recognised that there are additional opportunities to improve environmental performance, reducing energy costs and greenhouse gas emissions.

An eco-efficiency assessment conducted through the EPA's Cleaner Production Partnership Program identified potential annual savings of approximately $27 000 through initiatives such as efficient lighting and dual-flush toilets. Replacing electric water heaters with gas-operated units using existing hot-water units for storage can save around $17 000 annually, with a payback period of only about 1.2 years.

These changes have the potential to reduce energy consumption at Dockside Apartment Hotel by more than 3.38 MWh annually, reducing greenhouse gas emissions by 5.72 tonnes.

An eco-efficiency audit found further cost-saving measures for the Dockside Apartment Hotel. (Photo: EPA)

Agriculture and conservation

Case study: Red-Tip bananas

The marketing advantages of environmentally responsible farming practices have rapidly become evident to Frank and Dianne Sciacca at Mourilyan. As members of the marketing group Pacific Coast Eco-bananas, they won a Product and Services Marketing Award at the 2003 Queensland Primary Industries Achievements Awards.

The group markets Cavendish bananas under the 'Red-Tip' brand (**R**esponsible **E**nvironmental **D**evelopment—**T**aste good, **I**mportant nutrition, **P**roduced in Australia). With five ISO 14001 environmental management systems-accredited growers, Pacific Coast Eco-bananas has developed a business culture where quality, efficiency and innovation have become standard business practice. The group is strongly positioned in the marketplace to maintain and improve business viability while providing economic, environmental and social dividends.

The EPA is working in partnership with Pacific Coast Eco-bananas to further explore sustainable farming practices, the main focus being on improving on-farm biodiversity. The aim is to achieve sustainable production through integrated pest management strategies, minimising the environmental impacts of pesticides and herbicides and relying instead on soil technology to support rehabilitation of the soil biota.



Frank and Dianne Sciacca can use their ISO 14001 certification to assist the marketing of their 'Red-Tip' bananas. (Photo: EPA)

Pacific Coast Eco-bananas now offers a unique opportunity to build on the business benefits of sustainable farming practices and support eco-labelling and marketing through its supply chain.

Case Study: Working towards sustainability in central Queensland

The Fitzroy Basin Association (FBA) commissioned the Coastal Cooperative Research Centre to develop the Central Queensland Information Paper to assist its stakeholders in setting targets for natural resource management. This was the initial step in revising their strategy for sustainability.

The information paper identifies the region's critical assets, pressures and threats to them, their condition and trend and any knowledge gaps, and makes initial recommendations on targets (aspirational, resource condition and management actions). It also deals with the matters for targets set by the Commonwealth and state governments on land management, terrestrial biodiversity, inland aquatic ecosystems (rivers and offstream wetlands), estuarine, coastal and marine ecosystems, and water quality, as well as providing information on the social and economic context of the region.

CQ Information Paper sections	Land use and management	Terrestrial biodiversity	Inland aquatic ecosystems	Estuarine and marine aquatic ecosystems	Water quality		Social/economic issues		
					Rivers	Estuarine/ marine	Social capacity	Regional economy	Specific Indigenous issues
Commonwealth matters for targets	• Soil condition • Land salinity	• Native vegetation community integrity • Significant native species and ecological communities • Ecologically significant invasive species	• Inland aquatic ecosystems integrity • Significant native species and ecological communities • Ecologically significant invasive species	• Estuarine, coast and marine habitats integrity • Significant native species and ecological communities • Ecologically significant invasive species	• Nutrients • Turbidity • Surface water salinity • Human contaminants		• Socioeconomic profiling at a local government area level • Financial drivers within the region • Flow-on effects between industries		
Central Queensland Strategy for Sustainability issues dealt with	• Land use and management • Salinity • Urban areas	• Ecosystem health and biodiversity • Weeds	• River health		• Water quality		• Economic viability of industry • Rural community viability • Cultural heritage		

The state of the region information provides a basis to assist Central Queensland communities with target setting and developing management actions. It also provides a useful model for natural resource management planning in other regions. Source: Coastal CRC

Case study: Land for Wildlife

A voluntary, non-binding property registration scheme, Land for Wildlife encourages landholders to safeguard habitats for wildlife on their property. Through the program, landholders can obtain technical advice and support to develop and implement appropriate plans to maintain and enhance the ecological integrity and value of their properties.

On 30 June 2003 there were 2952 Land for Wildlife agreements covering 288 623 ha of land in Queensland. This included 32 925 ha of habitats identified as endangered or of concern.

In central Queensland, where 80 Whitsunday landholders are registered under Land for Wildlife, many of the agreements cover land containing Proserpine rock-wallaby habitat. The program focuses on educating landholders about the significance of their location and the dangers to the rock-wallabies posed by habitat fragmentation and the impacts of domestic cats and dogs.

The preservation of wildlife habitat on private land can make a very valuable contribution to plant and animal biodiversity, as it is often critical to maintaining essential corridors between isolated remnants of native habitat, enabling wildlife movement and genetic interchange.

Aquaculture

Case study: Rocky Point Prawn Farm

Rocky Point Prawn Farm, 50 km south of Brisbane, has gained certification for its environmental management system (EMS) under ISO 14001, a world first in aquaculture. This EMS is part of an overall system that aquaculture farmers can use to cope with the management of their environmental impacts while creating economic and market advantages for their business.

With both a quality management system (QMS) and an integrated environmental management system (IEMS) already in place, the farm had a sound basis for developing a certified EMS.

An EMS gap analysis was undertaken to identify the actions needed to qualify for ISO 14001 certification and provided the basis of an action plan to develop the EMS.

Some of the requirements for the ISO 14001 standard were met by the QMS; these included document control, non-conformance and corrective action procedures, system auditing and management review processes.

The managers of Rocky Point Prawn Farm believe that the process of developing their EMS provided a number of business benefits to the farm. Many standard farm practices were evaluated for the first time, providing the impetus for introducing new methods and practices, which will enhance business performance and deliver improved environmental outcomes.

This progressive farm is now establishing additional sustainable practices and is in a strong position to further capitalise on the process improvement already achieved.



Rocky Point Prawn Farm is a pioneer in managing the environmental impacts of aquaculture. (Photo: EPA)

Moving forward

The case studies in this chapter provide illustrations of the journey already begun. Before leaving this chapter, if we could with the wave of a wand fast-track the transition and transform our state using the principles and processes of sustainability, what would it look like? There is much to suggest that a sustainable Queensland would be a state where:

- the economy was competitive because of its innovative sustainable industries;
- biodiversity and ecological integrity were conserved, and economic incentives drove business opportunities in the conservation and enhancement of natural systems;
- eco-efficiency and resource productivity were motivated by full-cost pricing for products and services, taking into account all inputs (including the environment);
- Queenslanders lived on the interest of their natural capital;
- fairness was a basic precept in public discussions;
- risk, uncertainty and irreversibility were dealt with cautiously in public policy and development decisions;
- environmental assets were valued appropriately to reflect their vital function in supporting the state's living systems;
- society was characterised by wellbeing, intragenerational and intergenerational fairness, and community engagement; and
- the integration of environmental, social and economic goals in policies and activities was a fundamental element of governance and decision making.

Queensland can be sustainable, and the State Government has a pivotal role in leading the transition to sustainability. Sustainable development will build on our strengths, but it will require adjustment, reorientation and revaluation. The extent of the change will be as basic as our values and perceptions, and it will be reflected in the products and services of our economy, in the structures and fabric of our society, and in the policies and programs of government.

Sustainable development will require innovative governance, proactive policy formulation, supportive processes and institutional arrangements, public understanding and participation, coordination across the whole of government, better knowledge systems, adaptive management and social learning. The realisation of sustainability will also require new government competencies in using knowledge to lead change, promoting partnerships to achieve cooperative outcomes, and facilitating innovation by sharing risk and responsibility.

Above all, sustainability means aligning the expectations of government, industry and community more closely with the long-term interests of the people of Queensland. We can maintain our quality of life while assuring the children of tomorrow's Queensland of theirs. For that to occur, we all have to understand and be connected to what is happening, and be involved as part of the way forward.



Moving forward (Photo: Tourism Queensland)

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Towards sustainability (Photo: EPA)

3 Atmosphere

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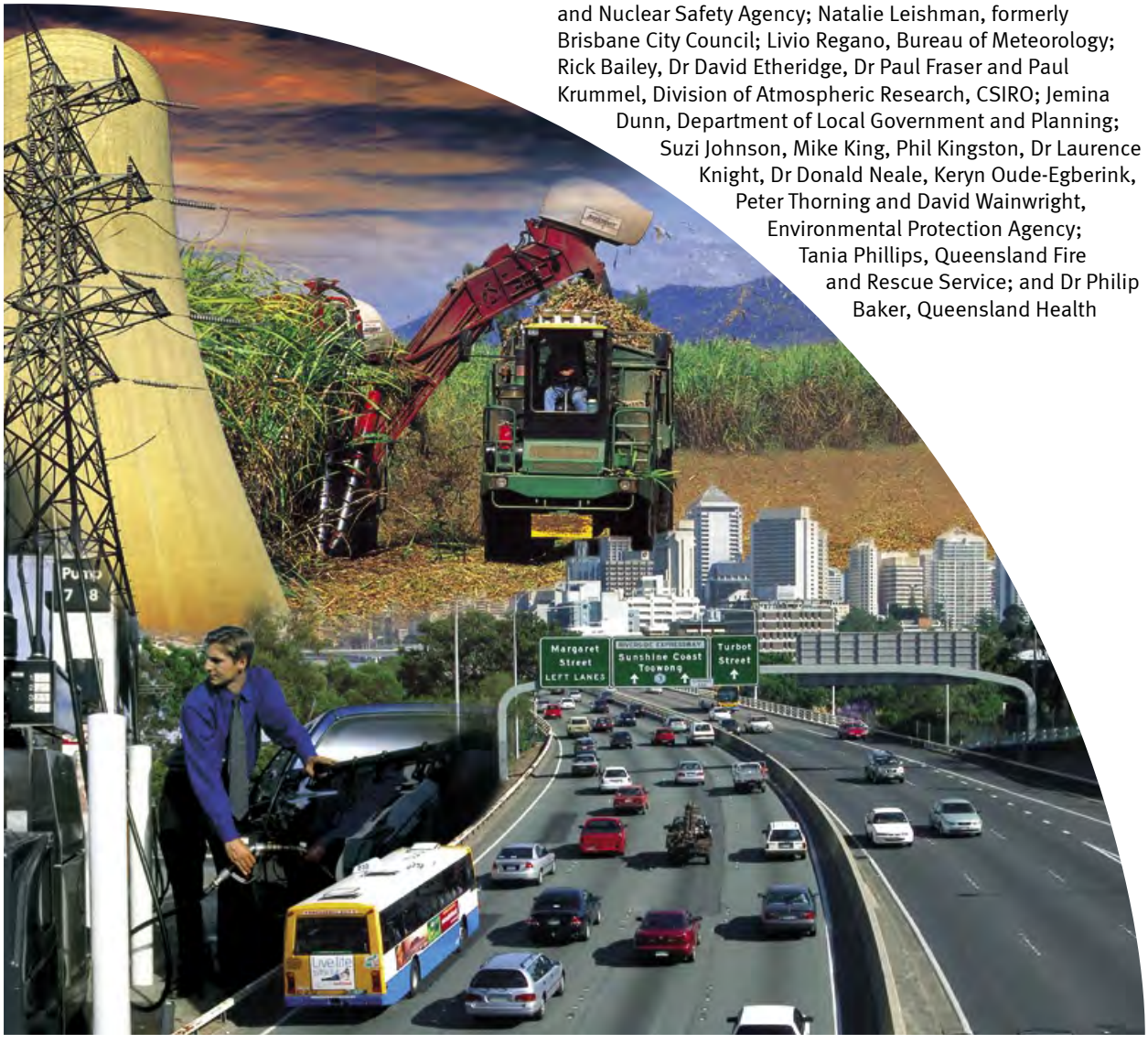
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Introduction

The atmosphere is a complex system of gases and airborne solid and liquid particles that surrounds the Earth. It is made up of several layers (figure 3.1). Most of the mass of the atmosphere is contained in the troposphere, in which we live and into which human emissions are released. The next layer, the stratosphere, contains the ozone layer that protects us from ultraviolet radiation from the Sun. The upper layers of the atmosphere include the mesosphere, thermosphere and exosphere. Table 3.1 shows the constituents of the atmosphere.

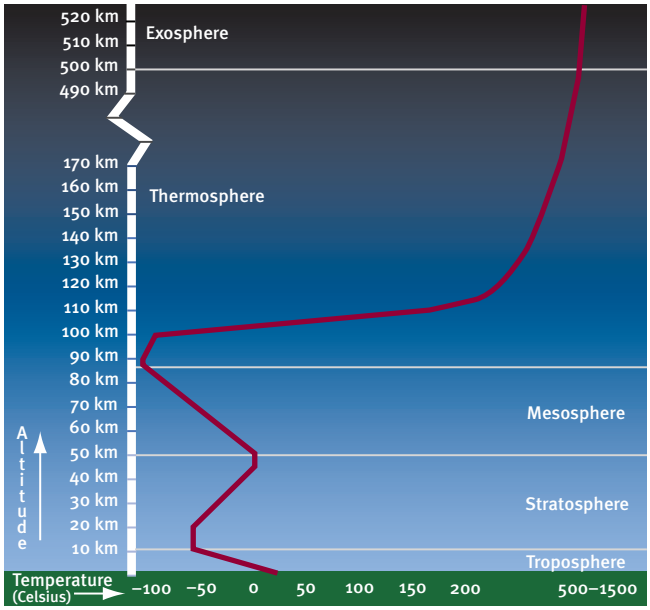


Figure 3.1 *Temperature profile and layers of the atmosphere Source: Windows to the Universe <http://www.windows.ucar.edu/> at the University Corporation for Atmospheric Research (UCAR). ©1995–1999, 2000 The Regents of the University of Michigan; ©2000–01 University Corporation for Atmospheric Research. All rights reserved*

Table 3.1 Constituents of the atmosphere

Constituent gas	Mean concentration (% v/v)
Nitrogen (N_2)	78
Oxygen (O_2)	21
Argon (Ar)	0.9
Water vapour (H_2O)	Variable: 0 to 3
Carbon dioxide (CO_2)	0.035
Methane (CH_4)	0.00017
Hydrogen (H_2)	0.00006
Nitrous oxide (N_2O)	0.000033
Carbon monoxide (CO)	0.000006 to 0.00002
Tropospheric ozone (O_3)	0.000001 to 0.00001
Stratospheric ozone (O_3)	0.00001 to 0.00005
Volatile organic compounds (VOCs)	0.00001 to 0.0001
Sulfur dioxide (SO_2)	0.0000001 to 0.00005
Nitrogen oxides (NO_x)	0.00000001 to 0.00005
Ammonia (NH_3)	0.00000001 to 0.000001
Perfluorocarbons (CFCs)	0.0000001
Peroxyacetyl nitrates (PANs)	0.0000001 to 0.000005

Source: EPA 1999c

The atmosphere helps to protect and support plant and animal life on Earth by maintaining our environment within a liveable temperature range and protecting us from harmful solar radiation. As society has evolved, however, human activities have imposed pressures on natural resources, including the atmosphere, and these affect the local and global air environment.

Global issues, such as climate variability, the enhanced greenhouse effect and stratospheric ozone depletion, are discussed in this chapter in the context of Queensland and Australia, where possible. Regional outdoor air quality issues, such as air quality, photochemical smog, visibility, particulate matter and the emerging concern about pollutants known as 'air toxics', are assessed for Queensland regions for which air quality monitoring data and information are available. Health research is now starting to focus more on the exposure of the population to pollutants (indoor air quality) than on ambient outdoor air quality levels, particularly for air toxics.

Through international agreements, Australia has continued to reduce its use of ozone-depleting substances such as CFCs. It is possible that the ozone layer may return to pre-1980 levels, resulting in the closing of the 'ozone hole' by 2050, if current measures continue to be implemented (WMO 2002). Australia's greenhouse gas emissions continue to increase. In Queensland, the energy sector and land clearing are two key contributors to greenhouse gas emissions. Legislation to control land clearing and strategies to use lower-intensity energy sources have been introduced to reduce greenhouse gas emissions in Queensland. The damage to the stratospheric ozone layer and enhancement of the natural greenhouse effect resulting from human activities create variations in the Earth's climate. Climate change predictions about increasing global temperatures and sea level changes have been made based on the current circumstances and possible scenarios for the 21st century.

Many of the pressures on local air quality affect the global air environment. For instance, motor vehicles, the major source of air pollution in urban areas, are also a source of greenhouse gases.

In most of Queensland, concentrations of pollutants in the ambient air are generally below concentrations allowed in national air quality standards. Concerns arise in some regions where industrial pollution or uncontrollable events, such as bushfires, cause intermittent exceedences of ambient air quality standards. Measures to reduce these occurrences and to improve general air quality are targeting the leading sources of air pollution. As traditional air pollutants, such as lead, are successfully removed from our environment, community awareness and concern turn towards other pollutants. Knowledge of the health effects of pollutants such as benzene, formaldehyde and toluene, known as 'air toxics', and their levels in Australia, is limited. Industry has begun reporting emissions of some of these air pollutants and governments are now monitoring levels.

This chapter focuses on ambient (outdoor) air quality, which is not necessarily an indicator of personal exposure to pollutants, such as benzene from cigarette smoke, which are likely to present a greater health risk than ambient concentrations of pollutants.

Climate variability

Summary

Weather, the term used to describe rainfall, temperature and wind, can affect current local air quality (see 'Photochemical smog', page 3.17), but climate, the long-term description of changes in these weather elements, tells us more about the changes in the systems of the planet. The global climate varies naturally due to fluctuations in the solar constant, the orbit of the Earth and natural phenomena such as the El Niño Southern Oscillation. The Earth's climate has changed on both global and regional scales since the pre-industrial era as a result of human activities (IPCC 2001). The impact of increased greenhouse gas emissions on the atmosphere has led to global effects such as higher sea levels and temperature variations, which have implications for Queensland's climate and environment.

Description

The Earth's climate is affected by the differences in incoming solar radiation at different latitudes, the tilt of the Earth's axis relative to the Sun, and the varying distance between the Earth and the Sun due to the Earth's elliptical orbit. Changes in solar radiation affect the Earth's climatic system through the atmosphere, ocean, biosphere, lithosphere and cryosphere. Components of the biosphere, such as terrestrial vegetation and phytoplankton in the upper ocean, influence climate on time scales ranging from seasons to decades. Adjustments in the lithosphere (continental land masses) and the cryosphere (continental ice sheets, sea ice, glaciers, snow cover and permafrost zones) occur on all time scales.

Part of the solar radiation is reflected by the atmosphere and the Earth's surface. The proportion reflected varies according to cloud cover, the amount of suspended particulate matter in the atmosphere and the reflectivity of the surface. The Earth's nearly spherical shape means that more intense solar radiation is received in the tropical regions around the equator. This results in net heating in the tropics and net cooling at the poles, which in turn generates thermally driven circulations in the atmosphere and the oceans. Warm air and water flow from the equator to the poles, and cool air and water flow from the poles to the equator.

Earth's ecosystems have evolved and adapted to natural climatic variability. Changes to the climate system caused by human interference must therefore remain within the bounds that the most sensitive life forms can tolerate if the natural ecological balance is to be maintained. The planet's energy balance and global climate are being affected by:

- greenhouse gas emissions, particularly carbon dioxide, methane and nitrous oxide;
- atmospheric aerosols, especially sulfates derived from fossil fuel combustion, biomass burning and other sources; and
- halocarbons affecting stratospheric ozone.



Climate change may affect rainfall patterns in Australia, causing decreases in water resources, land degradation and declines in agricultural yields. (Photo: EPA)

Climate change is predicted to adversely affect the Queensland environment through:

- increases in greenhouse gas emissions, causing rises in global surface temperatures and sea level, affecting coastal and low-lying areas by flooding. More severe cyclones in northern Queensland could double the area historically affected when flooding occurs. Cyclone intensity could increase in north Queensland by 20% by 2050 (AGO 2002);
- changes in rainfall patterns, with expected decreases in rainfall (+5% to -15% by 2030) along Queensland's coast, central west and northern regions, and subsequent impacts on surface water and groundwater resources, land degradation and impacts on agricultural practices and yields. Rainfall events may become more extreme, for example in northern Queensland, a current 1-in-40 year storm event may occur 1-in-15 years by 2050 (CSIRO 2001);
- stresses on terrestrial and marine ecosystems due to changes in sea level, rainfall and temperature that threaten susceptible species; and
- increases in energy demands and increased risk of wildfires associated with increased temperatures. Projections for 2030 indicate the average number of days above 35°C in Brisbane could increase from 3 days to 3–6 days. Mean annual temperatures in Queensland may increase by 0.3–2.0°C by 2030 (Walsh et al 2001).



The sun seen through smoke from bushfires at Mount Morgan in 1994. Changes in climate may lead to higher temperatures and greater risk of bushfires. (Photo: QFRS)

Climatic data for Queensland have been measured only since the 1800s, making it difficult to determine the reasons for variations in our climate. Studies of ice core samples, corals and other environmental factors can provide us with long-term climatic information that will enable us to determine whether climate variations are natural or induced by human activities.

Queensland's climate

The Bureau of Meteorology (BoM) has defined the major climate regions over Australia (figure 3.2). Queensland's northern tip, classified as equatorial and tropical, has a summer monsoon season and a mild, dry winter with clear skies. The state's inland regions are grassland, with warm to hot dry summers and warm, dry winters. Western Queensland's deserts experience hot, dry summers and winters. The rest of the state, along the eastern coastline, is subtropical, with warm, humid summers and fairly dry winters with clear skies.

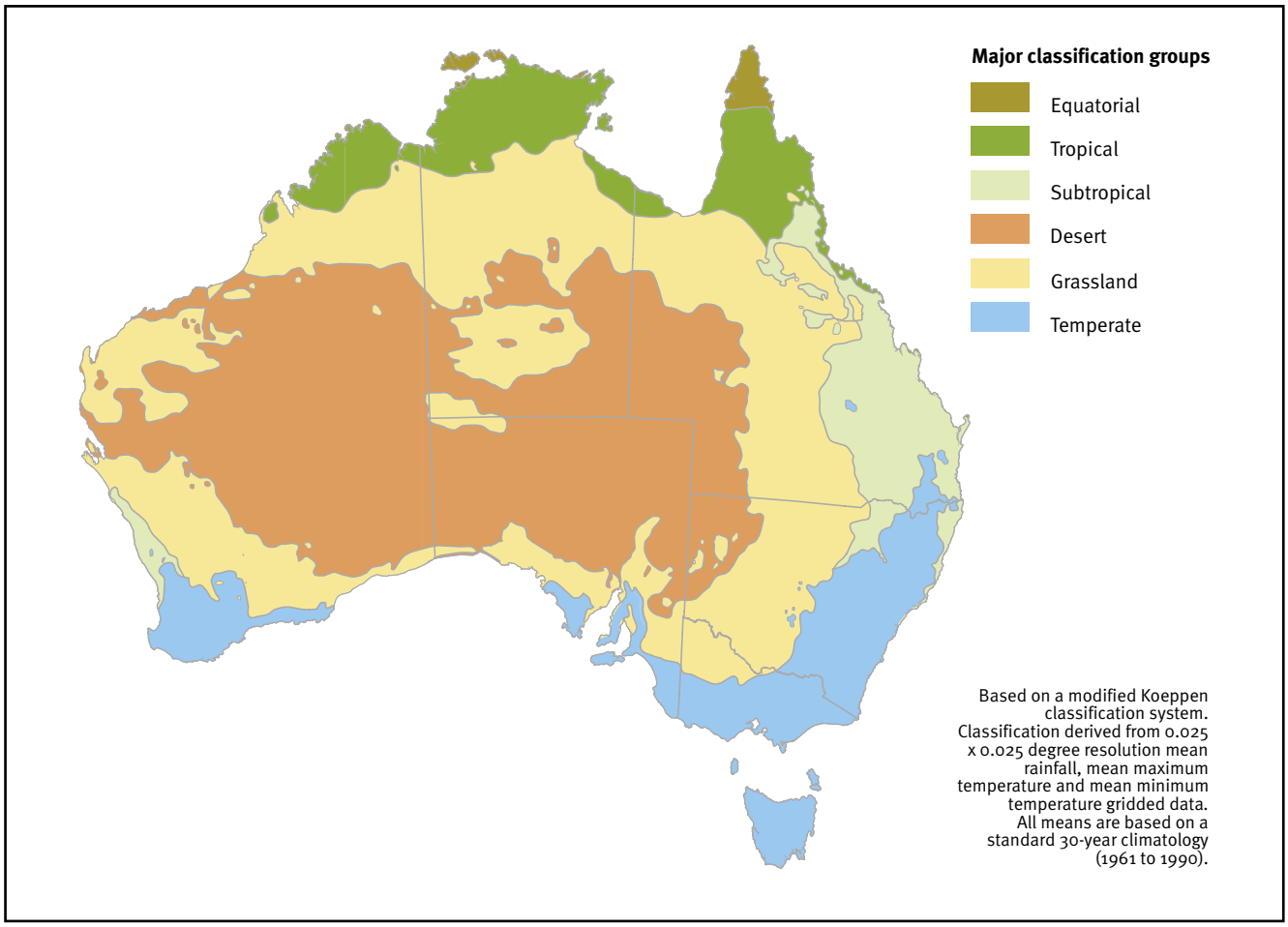


Figure 3.2 *Australia's climate regions*
Source: BoM



Western Queensland's deserts experience hot, dry weather during summer and winter. (Photo: EPA)



Storm clouds approaching Fraser Island (Photo: EPA)

Condition and trends

Climate is the statistical description of the state of the atmosphere (rainfall, temperature, wind, evaporation etc.) over periods significantly longer than the lifetimes of the individual weather-producing systems that affect it. Weather variables are described in terms of the averages, extremes, ranges, standard deviations and frequency distributions of the individual weather elements. Generally, the climate of a place or region consists of a range of conditions occurring over time. Historically, a 30-year period has been taken to approximate what is assumed to be a stable, long-term regime, or 'the normal climate'. The current standard 30-year climatology used to assess changes in Australia's climate is from 1961 to 1990 (BoM 2003).

Temperature

Air temperature varies widely across Queensland and is influenced by several factors. The tropical north experiences higher temperatures due to greater intensity of solar radiation. The cooling influence of the sea leads to lower temperatures in coastal areas than inland. Air temperature also decreases with altitude, resulting in lower temperatures in areas such as the Granite Belt and the Atherton Tableland. The highest temperature measured in Queensland in the period 1999–2003 was 47.4°C at Thargomindah on 15 January 2001; the second highest was 47°C, two days later, on 17 January at Birdsville.

The Bureau of Meteorology measures maximum and minimum temperatures around Queensland. Figure 3.3 shows a slightly increasing minimum temperature for Queensland, but no real change in the maximum temperature.

Rainfall

Queensland's summer rainfall declines with distance from the coast and winter rainfall declines with distance from the south. Local factors, such as proximity to the coast, altitude and topographic features, also modify climatic conditions to produce spatial variability in rainfall. Seasonal variability is also high, most of the state's rainfall occurring in the warmer summer months. Queensland's rainfall is highly variable from year to year (figure 3.4). South-east Queensland's driest three-year period since the 1930s began with the summer of 1999–2000; since then, the state has experienced three consecutive failed wet seasons.

The major influence on rainfall is the El Niño Southern Oscillation (ENSO) phenomenon (see page 3.7). Under El Niño conditions, the Southern Oscillation Index (SOI) is strongly negative and below-average rainfall is likely. In some locations, such as north-east Queensland, the chance of severe drought (less than 60% of average summer rainfall) doubles in El Niño years.

During the La Niña phase, the SOI is strongly positive and Queensland is likely to experience above-average rainfall with associated flooding. The strength of the correlation between rainfall and the SOI and the time of year when the correlation is strongest vary throughout Queensland. The strongest correlation is observed on the Darling Downs. As figure 3.4 shows, on a statewide basis the average rainfall varies with the SOI with reasonable consistency.

Meteorologists predicted an end to the current El Niño event in 2003, with Australia's most drought-affected areas expecting more winter and spring rains in 2003 than in 2002 (BoM 2003).

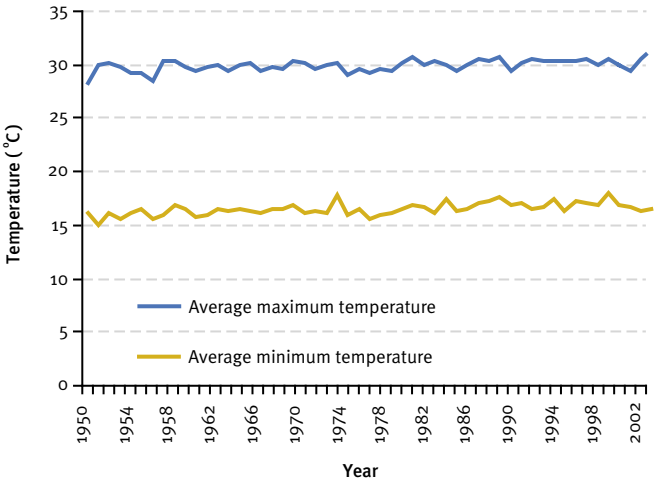


Figure 3.3 *Average annual mean maximum and minimum temperatures for Queensland, 1950–2002*
Source: BoM

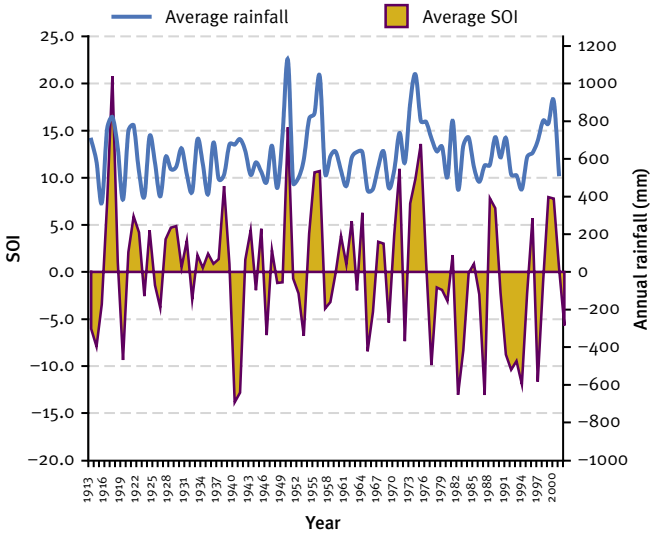


Figure 3.4 *Annual average Southern Oscillation Index (SOI) and annual average rainfall for Queensland, 1913–2002*
Source: BoM



Electricity generation at power stations is one of the main sources of greenhouse gases in Queensland. (Photo: EPA)

Pressures

Increased emissions of greenhouse gases and ozone-depleting substances cause changes in climate by increasing global temperatures, leading to changes in sea level and rainfall patterns.

Ozone-depleting substances attack the ozone layer, which protects the Earth from some of the ultraviolet radiation emitted by the Sun and helps to maintain the Earth's energy balance and climate. Many ozone-depleting substances are also greenhouse gases and contribute to global warming.

Greenhouse gases are produced by the burning of fossil fuels for energy generation, transport and industrial processes. Australia is one of the highest per capita emitters of greenhouse gases due to its dispersed population, high dependence on private transport and reliance on energy-intensive fossil fuels such as coal. Queensland, in particular, relies heavily on coal, using it as the main fuel for electricity generation. Recent land management practices, which resulted in significant land clearing and greenhouse gas emissions, are also a concern, as retention and increase of vegetation cover are an important mitigator of greenhouse gas emissions.

Summary of condition and trend indicators

Climate variability

Indicator	Queensland/Australia
Southern Oscillation Index	▼
Daily and extreme rainfall	?
Average maximum and minimum temperatures	?

Key to condition:

Good

Moderate

Poor

Not assessed

Key to trend:

▼ Decreasing
▲ Increasing
? Uncertain
– No change
x Not assessed

Responses

In 1992 Australia, along with other countries, signed the United Nations Framework Convention on Climate Change (UNFCCC). The UNFCCC aims to stabilise greenhouse gas concentrations to prevent human activities from influencing the climate system. The Australian Greenhouse Office, a Commonwealth Government agency, was established to oversee the development and implementation of national greenhouse policy and actions. As part of its obligations under the UNFCCC, the Australian Greenhouse Office undertakes annual greenhouse gas emission inventories for Australia and leads the National Greenhouse Strategy (AGO 1998).

In 1997 Australia committed to the Kyoto Protocol, a legally binding agreement under the UNFCCC for countries to reduce greenhouse gas emissions in order to protect the climate from change. Australia negotiated an 8% increase in emissions over its 1990 levels, but most countries are required to reduce their greenhouse gas emissions by at least 5% by 2008–12. Australia is yet to ratify the Kyoto Protocol and greenhouse gas emissions in 2000 are estimated as 6.3% higher than 1990 levels (AGO 2002).

The Intergovernmental Panel on Climate Change (IPCC) is an international group of scientists whose role is to advise world governments on climate change science. The IPCC prepares assessment reports on climate change based on scientific, technical and socioeconomic information. In 2001, the IPCC released its Third Assessment Report on climate change, which includes the following findings:

- there is evidence to suggest that most of the Earth's warming over the past 50 years was caused by human activities;
- in the past 100 years the Earth's average surface temperature has increased by between 0.4°C and 0.8°C;
- average global surface temperatures are expected to increase by between 1.4°C and 5.8°C between 1990 and 2100; and
- by 2100 the average sea level will increase by 9–88 cm above 1990 levels.

Queensland has incorporated parts of the National Greenhouse Strategy in the *Queensland Implementation Plan* (EPA 1999a) and *The Queensland Greenhouse Policy Framework: A Climate of Change* (EPA 2001c), targeting areas where greenhouse gas emissions can be reduced and managed. See 'Enhanced greenhouse effect' (page 3.8) for further information on how greenhouse gas emissions are being managed in Queensland.

El Niño Southern Oscillation (ENSO) phenomenon

El Niño is a Spanish term meaning 'the Christ child'. It is traditionally used by fishers to describe a warm ocean current that arrives off the coast of Ecuador and Peru, often near Christmas. The El Niño current affects traditional anchovy fishing in the region by bringing warm, low-nutrient water from the Pacific Ocean to the South American coastline. This prevents the usual upwelling of colder, nutrient-rich water from the deeper ocean of Antarctica, which provides abundant plankton on which the anchovy stocks feed. The term El Niño is now used widely to describe the changes in global weather patterns due to changes in the circulation of the atmosphere and warm water across the eastern Pacific Ocean, influencing rainfall in Queensland.

Under normal circulation conditions, the cold, deep ocean waters that travel up to the Peruvian coast then flow west across the Pacific Ocean towards Australia and are heated by the Sun, resulting in warmer waters off Australia's coast than off South America. Easterly trade winds that move along the equator towards northern Australia bring warm, moist air into the atmosphere over the warmer seas. As the rising air cools, it produces low air pressures, clouds and rain across northern Australia. The air then moves eastward at high altitude, sinking back over the Pacific Ocean, producing high pressure systems of dry air as it warms. This atmospheric circulation is known as the Walker circulation (figure 3.5).

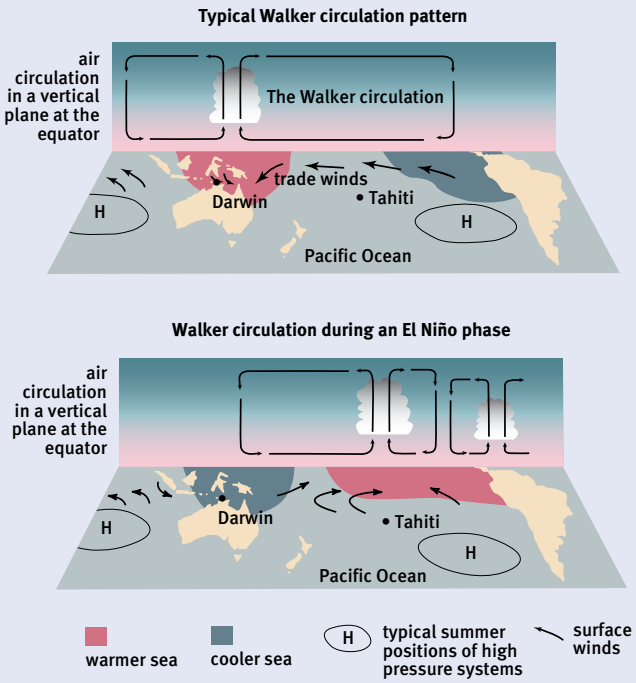


Figure 3.5 *Walker circulation under typical conditions and under El Niño conditions*
Source: BoM

Under El Niño conditions, the difference between Pacific Ocean temperatures off the Australian and South American coasts diminishes and the Walker circulation and trade winds weaken. The rising of moist air occurs over the central Pacific Ocean, resulting in less rain for eastern and northern Australia. Figure 3.6 shows El Niño-related drought areas in Australia since 1965.

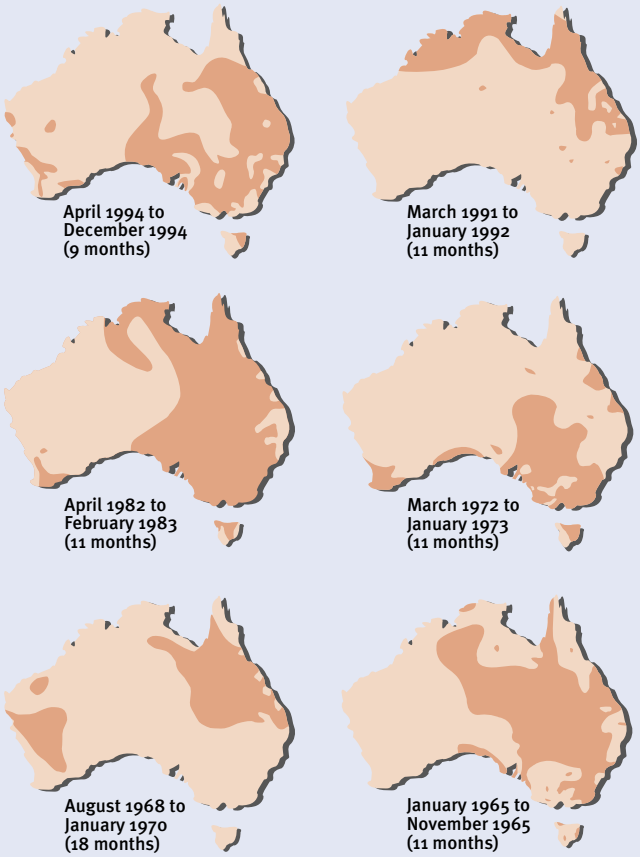


Figure 3.6 *El Niño-related drought areas (shaded darker) in Australia since 1965*
Source: BoM

The term 'southern oscillation' was used to describe a tendency for atmospheric pressure over the Pacific Ocean to increase when pressure over the Indian Ocean decreased and vice versa. It is now used to describe large changes in the Walker circulation associated with the pattern of tropical Pacific Ocean surface temperatures.

The Southern Oscillation Index (SOI) is a simple measure of the strength and phase of the southern oscillation, indicating the condition of the Walker circulation. The SOI is the difference in air pressure between Darwin, on the eastern edge of the Indian Ocean, and Tahiti in the central Pacific Ocean. Under normal conditions, the SOI is close to zero. In the El Niño phase of the southern oscillation, the SOI is strongly negative and below-average rainfall is likely to occur in Queensland. When the SOI is strongly positive, the southern oscillation is in the anti-El Niño, or La Niña, phase and above-average rainfall is likely in eastern and northern Australia, possibly causing flooding.

Enhanced greenhouse effect

Summary

The greenhouse effect occurs when energy from the Sun is trapped in the Earth's atmosphere by greenhouse gases. Carbon dioxide (CO_2), nitrous oxide (N_2O) and methane (CH_4) are gases that contribute to the greenhouse effect, which helps to maintain the Earth's energy and temperature balance. The *enhanced* greenhouse effect, due to increases in greenhouse gases because of human activities, magnifies the natural process and causes changes to the global climate, including rises in sea level and temperature. The major contributors to greenhouse gas emissions in Queensland are land clearing, electricity generation, agriculture and transport. Greenhouse gas emissions and atmospheric concentrations continued to increase in the 1990s. Strategies are in place to limit the amounts of greenhouse gases emitted.

Description

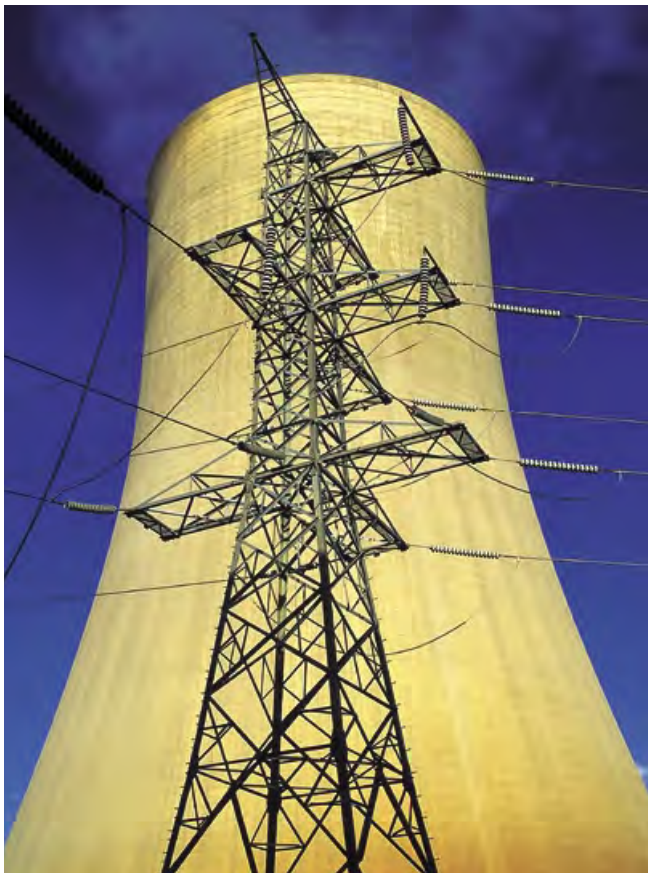
The Earth's climate has changed over the past century as a result of human-generated emissions of greenhouse gases to the atmosphere. Adverse impacts of climate change, due to increases in greenhouse gases, that may affect Queensland include:

- more extensive storm tide flooding and erosion of coastal areas and infrastructure associated with sea level rises and more intense cyclones;
- changes in the characteristics of surface water and groundwater resources due to reductions in annual rainfall and increased rainfall intensity;
- increased vulnerability to land degradation as a result of salinity and soil erosion, and accompanying nutrient loss, associated with increased rainfall intensity;
- alteration to crop growth seasons and the ability of some regions to sustain current agricultural practices in the light of variations in maximum and minimum temperatures and water availability;
- increased stress imposed on terrestrial and marine ecosystems by a number of temperature- and rainfall-related factors, such as coral bleaching, resulting in loss of biodiversity;
- increased flood risk and damage to transport infrastructure and low-lying human settlements, which may result in isolated communities having inadequate supplies of safe, unspoiled food;
- increased risk of bushfires;
- changes in energy demand and peak load associated with lower minimum temperatures in winter and increased maximum temperatures in summer, which could increase the number of heat-related deaths; and
- changes in human and animal health resulting from heat stress and changes in the location of current vector-borne diseases and pest and weed populations (EPA 2003d). For example, the incidence of diarrhoea generally increases with warmer weather and higher temperatures promote bacteria such as *Eschericia coli* in contaminated foods. Upgraded sewerage systems and safer food production and storage processes may be required for the protection of health.

Increased severe storm activity (such as floods, cyclones and storm surges) can result in direct loss of life, injury and loss of or damage to habitat. McMichael et al. (2003) predict that annual flood-related deaths and injuries may increase by up to 240% by 2020.

In 1997 Australia committed to the Kyoto Protocol, an international agreement that sets future emission targets for developed countries. Australia's target is to limit greenhouse gas emissions to 108% of its 1990 levels over the period 2008–12. Australia is yet to ratify the protocol, however. Estimates indicate that in 2001 Australia's greenhouse gas emissions were 2.4% higher than 1990 levels. Amongst industrialised countries, Australia has one of the highest emissions per capita (AGO 2003).

Australia's abundance of and dependence on fossil fuel resources is a key factor in its high emissions of greenhouse gases. Its use of fossil fuels extends across the energy generation, transport, industrial and economic sectors. Queensland, in particular, relies heavily on coal for electricity generation. Approximately 88% of electricity generated in Queensland is fuelled by coal (ABARE 2003). Land clearing is the other major source of greenhouse gas emissions in Queensland. Better management of forests and vegetation as sinks of greenhouse gases and use of renewable and lower-intensity energy sources are important factors in limiting Queensland's future greenhouse gas emissions and the impacts of the enhanced greenhouse effect.



Most of Queensland's electricity is generated in coal-fired power stations. More than one-third of Queensland's greenhouse gas emissions result from burning fossil fuels for our electricity supply. (Photo: EPA)



Climate change may cause an increased flood risk in Queensland. (Photo: DNRM)

Condition and trends

Australia is one the world's highest per capita emitters of greenhouse gases and produced the equivalent of 528.1 million tonnes of CO_2 in 2001 (AGO 2002). Queensland produced the equivalent of 135.2 million tonnes of CO_2 (135.2 million CO_2^{-e} tonnes) in 1999; the state's per capita emissions are higher than the national average (Qld Treasury 2001). Table 3.2 shows estimates of greenhouse gas emissions by key sector for Australia (2001) and Queensland (1999). The two sectors responsible for close to two-thirds of greenhouse gas emissions in Queensland are stationary energy, and land use change and forestry. The significant causes of emissions from these two sectors are Queensland's use of fossil fuels (coal) and extensive land clearing. In 1999, Queensland had a higher proportion of greenhouse gas emissions generated from land clearing than did the rest of Australia. Overall, the largest contributor to greenhouse gas emissions in Australia is the energy sector.

Table 3.2 Australian and Queensland net greenhouse gas emissions, 2001 and 1999

Sectors/key subsectors	Australia 2001[a]		Queensland 1999[b]	
	Million tonnes	Relative contribution (%)	Million tonnes	Relative contribution (%)
Energy	**369.0**	**69.9**	**71.8**	**53.1**
Stationary energy	259.5	49.1	50.5	37.3
Transport	77.2	14.6	15.4	11.4
Fugitive fuels	32.2	6.1	5.9	4.3
Industrial processes	**24.9**	**4.6**	**1.8**	**1.3**
Agriculture	**105.8**	**20.0**	**25.1**	**18.5**
Livestock	68.3	12.9	21.0	15.5
Other agriculture	37.5	7.1	4.1	3.0
Waste	**17.1**	**3.2**	**3.1**	**2.3**
Land use change and forestry*	**11.4**	**2.2**	**33.5**	**24.7**
Total	**528.1#**	**99.5**	**135.2**	**99.5**

* Land clearing emissions and forestry sinks combined, based on UNFCCC accounting

25.9MT based on Kyoto accounting

Sources: [a]AGO 2003; [b]Qld Treasury 2001

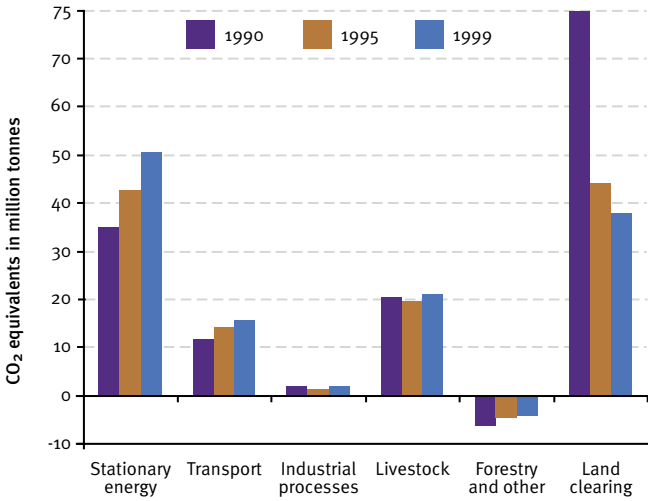


Figure 3.7 *Greenhouse gas emissions by major subsectors, Queensland, 1990–99*
Sources: Qld Treasury 2001; AGO pers. comm.

Queensland's greenhouse gas emissions from the energy sector grew steadily during the 1990s, with emissions from transport and stationary energy sources rising by 31% and 44% respectively between 1990 and 1999 (figure 3.7). In contrast, emissions from industrial processes and livestock were relatively stable.

The situation in relation to land use change and forestry is more complex. Data from the Australian Greenhouse Office (AGO) point to a contraction in greenhouse sinks from forestry and other sources between 1990 and 1999, which was more than offset by a substantial reduction in emissions in land clearing. However, the AGO data do not appear to reflect the spike in land clearing that took place in 1999–2000, when the area cleared increased by 78% and then fell by 50% in 2000–01 in association with the implementation of the *Vegetation Management Act 1999* (table 3.3).

Table 3.3 Land clearing in Queensland, 1997–2001

Year	Ha cleared	Percentage change (1997–99 basis)
1997–99	425 000	
1999–2000	758 000	+78
2000–01	378 000	–11

Source: DNRM 2003

Atmospheric concentrations of methane (CH_4), nitrous oxide (N_2O) and carbon dioxide (CO_2) are measured at locations around the world, including Cape Ferguson near Townsville and Cape Grim in Tasmania (figure 3.8). These stations provide information about the seasonal and annual variability of greenhouse gases in the global atmosphere.

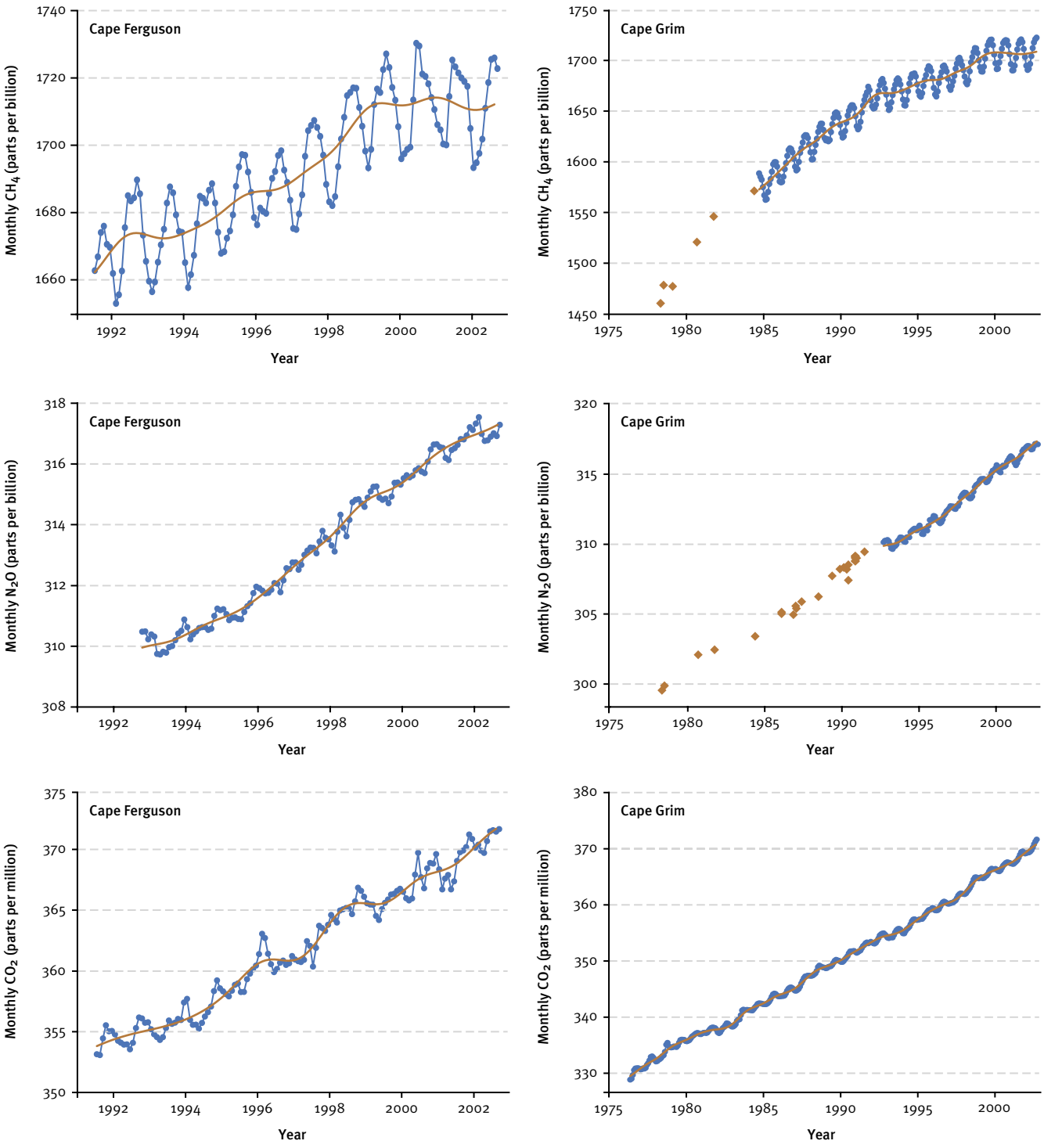


Figure 3.8 Trends in concentrations of various greenhouse gases in Australia, measured at Cape Ferguson, near Townsville (1992–2002), and Cape Grim, Tasmania (1975–2002)

Concentrations of these greenhouse gases vary seasonally, but continue to increase. Carbon dioxide concentrations grow by between one and three parts per million (ppm) a year. Methane concentrations increased at a lower rate in the 1990s than in the previous decade. Nitrous oxide has a slower growth rate than carbon dioxide (Manins et al. 2001).

Pressures

Australia's abundance of and high dependence on fossil fuels for transport, its dispersed population and high population growth are accentuated in Queensland, whose economy and lifestyles are largely built upon the use of fossil fuels, particularly coal. The state's economy is based on the energy, agricultural, mining and mineral sectors. Land clearing in Queensland remains a concern as vegetation is an important sink of greenhouse gases. Sustainable land management practices are an important factor in limiting greenhouse gas emissions. See Chapter 4, 'Land, soil fertility decline and soil carbon'.

Summary of condition and trend indicators

Enhanced greenhouse effect

Indicator	Queensland/Australia
Greenhouse gas atmospheric concentrations	▲
Annual greenhouse gas emissions	▲

Key to condition:

- Good
- Moderate
- Poor
- Not assessed

Key to trend:

- ▼ Decreasing
- ▲ Increasing
- ? Uncertain
- – No change
- X Not assessed

Responses

Government, industry and the community are all working to reduce greenhouse gas emissions. Government policies and strategies have been put in place to help the wider community limit Australia's greenhouse gas emissions.

The National Greenhouse Strategy is the primary mechanism through which Australia will contribute to reducing greenhouse emissions to meet its obligations under the 1997 Kyoto Protocol (AGO 1998). (See 'Climate variability', page 3.3)

The National Greenhouse Strategy aims to:

- foster knowledge and understanding of greenhouse issues;
- limit greenhouse emissions and enhance greenhouse sinks; and
- provide the foundations for adaptation to climate change through specific measures.

The *Queensland Implementation Plan* (EPA 1999a) for the National Greenhouse Strategy and *The Queensland Greenhouse Policy Framework: A Climate of Change* (EPA 2001c) deal with areas such as transport, cleaner and more efficient energy use, urban planning, livestock management, industry best practice, mineral processing and mining, sustainable land management, emissions trading and education.

Key objectives of the *Queensland Energy Policy: A Cleaner Energy Strategy* (Qld Treasury 2000) are to move the state's energy mix towards greater use of natural gas and renewable resources, reduce the growth in greenhouse gases, and ensure that the greenhouse impacts of energy generation are appropriately managed. Key initiatives of the strategy are outlined in Human Settlements, page 8–28. Government initiatives relating to the reduction of greenhouse emissions from coal include the key government research priority of *Environmentally Sustainable Queensland—Managing Climate Change*, which will support research into predicting climate change, management and mitigation strategies, and technologies for clean and efficient energy production. In 2003 the government announced the Centre for Low Emission Technology, which will facilitate research and development into clean coal technologies and carbon dioxide capture and storage technologies, some of which may have the potential to substantially reduce greenhouse emissions from the use of coal.

The introduction of the *Vegetation Management Act 1999* coincided with a reduction in land clearing across Queensland. The area cleared in 2000–01 was 11% lower than that cleared in the 1997–99 period (table 3.3). Illegal land clearing can be detected by satellite imagery and landholders may be prosecuted under the legislation. The *South East Queensland Forestry Agreement*, signed in 1999 between the Queensland Government and other parties, aims to reduce greenhouse gas emissions from vegetation removal by increasing the amount of protected forests in Queensland.



Livestock contribute 15% of the state's greenhouse gas emissions. (Photo: EPA)

Stratospheric ozone depletion

Summary

Ozone is a naturally occurring gas that is a pollutant in the troposphere, the lowest layer of the atmosphere (figure 3.1). Most ozone (90%) is found in the next layer of the atmosphere, the stratosphere, where it protects the Earth by absorbing some of the ultraviolet (UV) radiation from the Sun so that the Earth's biological processes can occur. In this 'ozone layer', human-made substances, called ozone-depleting substances (ODSs), can react in the presence of the UV radiation to destroy the ozone molecules that protect us. The depletion of the ozone layer in the upper atmosphere reduces our protection from solar UV radiation and may have impacts on our health and environment, such as increased incidence of skin cancers and eye disorders and adverse effects on plant growth.

The destruction of the ozone layer is most severe over Antarctica each spring, when what has become known as the 'ozone hole' develops as a result of low ozone levels in the region. International action has been taken to reduce the concentrations of the substances that deplete the ozone layer by phasing out their use. As these ODSs are very stable, however, it will take many years for the ozone layer to recover. The hole in the ozone layer over Antarctica should close by the middle of the 21st century provided that the Montreal Protocol on Substances that Deplete the Ozone Layer and its amendments are adhered to (WMO 2002).

Description

The amount of ozone in the stratosphere varies according to latitude, seasons, stratospheric winds and the 11-year sunspot cycle. The ozone layer over Antarctica is at its thinnest during the Southern Hemisphere spring. This annual thinning of the ozone layer became commonly known as the ozone hole after concerns were raised in the 1970s about the implications and effects of human-made ODSs, which, when they reach the stratosphere, reduce the concentration of ozone that protects us from solar UV radiation.

ODSs have been used for many purposes:

- chlorofluorocarbons (CFCs)—refrigeration, foam-blowing agents, aerosol propellants and solvents;
- hydrochlorofluorocarbons (HCFCs)—as replacements for CFCs, mainly as refrigerants;
- bromochlorofluorocarbons (halons)—firefighting agents;
- methyl bromide—agricultural and building fumigant;
- carbon tetrachloride—cleaning solvent and used in the manufacture of CFCs; and
- methyl chloroform—cleaning solvent.

The damage to the ozone layer is expected to have environmental and health effects through the adverse effects of increased UV radiation. UV radiation is greatest at the equator and decreases with increasing latitude. Brisbane has the second highest UV index of any Australian capital city, after Darwin (Manins et al. 2001). It has been suggested that eye cataracts, skin cancers and reduced immune system functions can be caused by UV radiation and that the incidence of these could increase as a result of the depletion of the ozone layer (UNEP 2003a).

UV radiation can adversely affect the development and reproduction of fish, amphibians and aquatic organisms including phytoplankton and zooplankton, and has effects further up the food chain. Studies of plant species indicate that some are sensitive to increased UV radiation levels; this has implications for biodiversity and agriculture (UNEP 2003a).

The amount of ozone in the stratosphere is measured in Dobson Units (DU). Typical concentrations range from 200 DU near the equator to 400 DU at the north and south polar regions. The most severe ozone depletion occurs as the ozone hole over Antarctica during spring, when ozone concentrations as low as 100 DU have been measured (WMO 2002). Queensland ozone losses are estimated at about 1% per decade, compared to 4% for southern states (Manins et al. 2001).

The phasing-out of the use of ODSs under the Montreal Protocol and its additions and amendments is beginning to result in reductions of some of these substances and will result in an eventual reduction in the size of the ozone hole over Antarctica.

Condition and trends

Figure 3.9 shows the concentration of selected ODSs in the troposphere (ground level) at Cape Grim in Tasmania from 1978 to 2002. Concentrations measured in parts per trillion (ppt) increased rapidly until the early 1990s, when strategies were implemented to reduce and phase out the use of ODSs. As ODSs are very stable they can exist in the atmosphere for many decades, but overall they have been declining after peaking in the years 1992–94. Concentrations of carbon tetrachloride and methyl chloroform have been decreasing since the early 1990s. Levels of CFC-11 and CFC-113 appear to be gradually decreasing. These substances were phased out of use and replaced with others, such as HCFCs, that are less ozone-depleting. The rate of increase of CFC-12 has slowed in recent years.



The Cape Grim baseline air pollution monitoring station in Tasmania is the joint responsibility of the Bureau of Meteorology and CSIRO. Its measurements of concentrations of greenhouse gases and ozone-depleting substances are used in global research about the greenhouse effect and the stratospheric ozone layer. (Photo: D. Whillas, CSIRO Atmospheric Research)

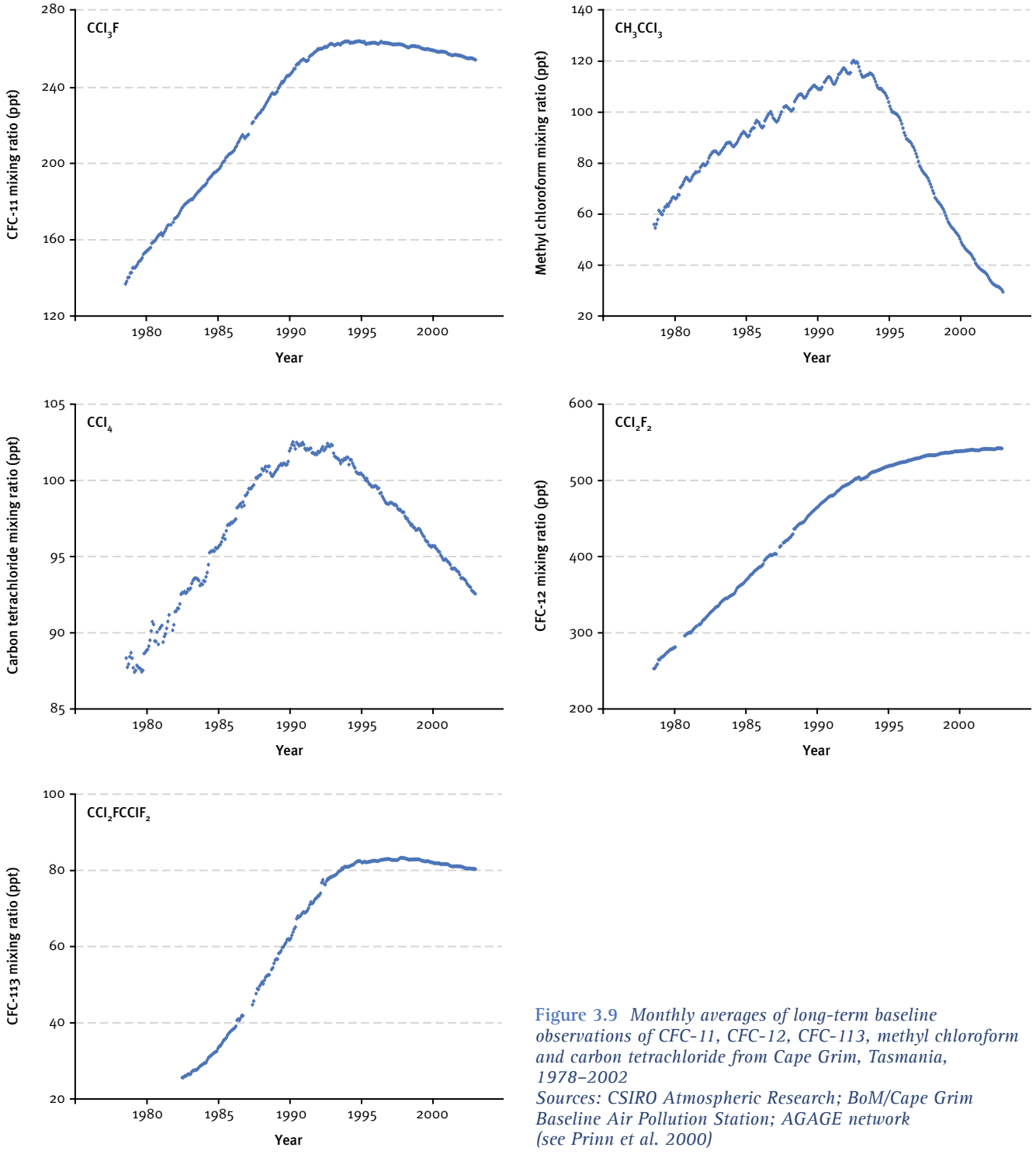


Figure 3.9 *Monthly averages of long-term baseline observations of CFC-11, CFC-12, CFC-113, methyl chloroform and carbon tetrachloride from Cape Grim, Tasmania, 1978–2002*
Sources: CSIRO Atmospheric Research; BoM/Cape Grim Baseline Air Pollution Station; AGAGE network (see Prinn et al. 2000)

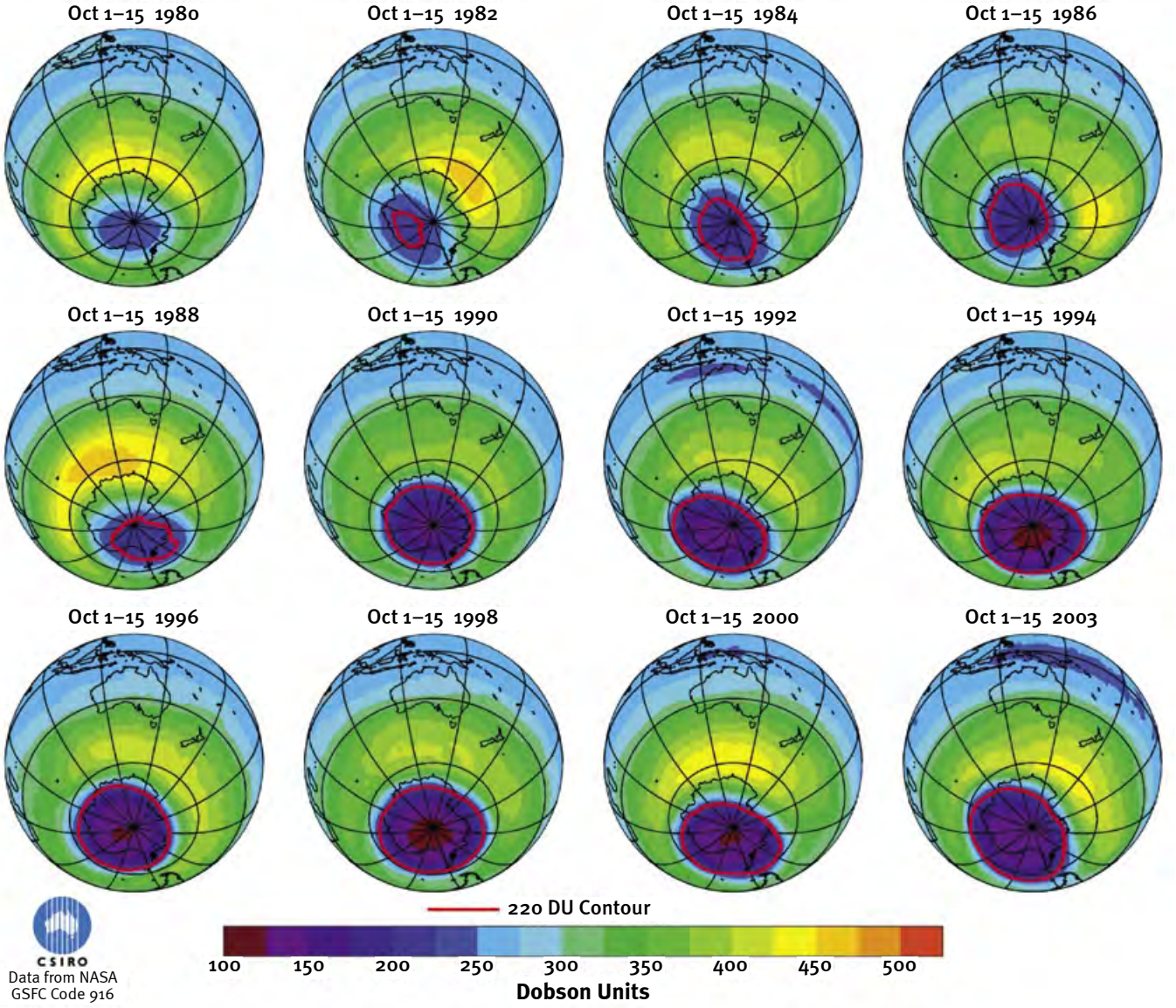


Figure 3.10 *Ozone distributions over the Southern Hemisphere, 1980–2003*

Figure 3.10 shows the variation in stratospheric ozone levels in Dobson Units (DU) over the Southern Hemisphere since 1980. Ozone levels across Australia are now around 6% lower than pre-ozone hole levels in 1980 (UNEP 2003b; WMO 2002).

The Antarctic ozone hole is defined as the area where ozone levels are less than 220 DU (the darker blue to maroon in figure 3.10). The hole has grown over the past two decades, but its size varies from year to year due to meteorological factors including stratospheric temperatures and winds as well as events such as the 1991 eruption of Mount Pinatubo in the Philippines. The volcanic eruption resulted in an injection of volcanic aerosols into the stratosphere; levels did not stabilise until 1999, when the aerosols were eventually removed (UNEP 2003b). The area, depth and duration of the ozone hole are all factors that add to its variability each year. The ozone hole reached its largest recorded area, 29 million square kilometres, more than three times the size of Australia, in September 2000. It was smaller in 2001 and 2002 due to yearly variations in climatic conditions (Goddard Space Flight Center 2002). Scientists suggest that levels of ODSs in the atmosphere will fall sufficiently by the middle of this century to return to below 1980 levels, ending the occurrence of the Antarctic ozone hole (WMO 2002).

Pressures

Releases of ODSs are now limited by the Montreal Protocol, which sets a schedule for the phasing-out and replacement of the use of CFCs and other ODSs to protect the ozone layer. In the short term, HCFCs are being used as an interim replacement for CFCs, halons and chlorinated solvents as they are less ozone-depleting.

The ozone-depletion potential and lifetimes of ODSs in the atmosphere and the use of ODSs by countries that are not parties to the Montreal Protocol, particularly developing countries, are factors that will affect the recovery of the ozone layer. Table 3.4 shows the ozone-depletion potential (ODP) of selected controlled substances under the Montreal Protocol. Many ODSs are very stable and will remain in the atmosphere, impacting on the ozone layer for their lifetime. Methyl chloroform has an estimated lifetime in the atmosphere of five years; by comparison, carbon tetrachloride is estimated to have a lifetime of around 26 years (WMO 2002). Many others have longer lifetimes. Due to the substantial reductions in emissions of ODSs made by developed countries under the Montreal Protocol during the 1990s, the use of these substances in developing countries has now become a significant contributor to global emissions.

Table 3.4 Ozone-depletion potential (ODP) of selected controlled substances under the Montreal Protocol

Substance	ODP
CFC-11 (CCl_3F)	1.0
CFC-12 (CCl_2F_2)	1.0
CFC-113 ($C_2Cl_3F_3$)	0.8
Carbon tetrachloride (CCl_4)	1.1
Methyl chloroform (CH_3CCl_3)	0.1
Halon-1211 (CF_2BrCl)	3.0
Halon-1301 (CF_3Br)	10.0
Halon-2402 ($C_2F_4Br_2$)	6.0
HCFC-22 (CHF_2Cl)	0.055

Source: UNEP 2000

Summary of condition and trend indicators

Stratospheric ozone depletion

Indicator	Queensland/Australia	
Concentration of ozone-depleting substances in the atmosphere	▲	▲
Stratospheric ozone concentration	▼	▼
Recovery and destruction of ozone-depleting substances	▲	

Key to condition:

Good

Moderate

Poor

Not assessed

Key to trend:

▼ Decreasing
▲ Increasing
? Uncertain
– No change
X Not assessed

Responses

The United Nations Environment Programme (UNEP) has been working to protect the ozone layer since the mid-1970s. The 1985 Vienna Convention for Protection of the Ozone Layer was established as a result of international concern about ozone depletion and the discovery of the seasonal occurrence of the Antarctic ozone hole. In 1987 the European Economic Community and 32 countries, including Australia, adopted the Montreal Protocol on Substances that Deplete the Ozone Layer. It introduced a number of measures and a timetable for action to regulate the release of the most common CFCs into the environment. More countries have since agreed to the Montreal Protocol, totalling 180 countries in 2001 (UNEP 2001), and amendments have been made to accelerate the phasing-out of the use of some ODSs and to include additional substances. Since 1987, the Montreal Protocol has been amended at Conventions for Protection of the Ozone Layer in London (1990), Copenhagen (1992), Vienna (1995), Montreal (1997) and Beijing (1999).

The production of the most damaging ODSs (including CFCs and halons) was eliminated, except for a few critical uses, by 1996 in developed countries, and will be eliminated by 2010 in developing countries. The timetable for the phasing-out of ODSs is constantly revised in response to improved scientific understanding and measurements of ODSs and ozone layer concentrations.

The Montreal Amendment of 1997 finalised the schedules for phasing out methyl bromide. The Beijing Amendment of 1999 included bromochloromethane for immediate phase-out; it also introduced production controls on HCFCs as well as controls on trade with non-parties. Table 3.5 shows the Montreal Protocol schedule for the phasing-out of ozone-depleting substances (EA 2003a).

Table 3.5 Summary of Montreal Protocol control measures

Ozone-depleting substances	Developed countries	Developing countries
Chlorofluorocarbons (CFCs)	Phased out end of 1995[a]	Total phase-out by 2010
Halons	Phased out end of 1993	Total phase-out by 2010
Carbon tetrachloride	Phased out end of 1995[a]	Total phase-out by 2010
Methyl chloroform	Phased out end of 1995[a]	Total phase-out by 2015
Hydrochlorofluorocarbons (HCFCs)	Freeze from beginning of 1996[b] 35% reduction by 2004 65% reduction by 2010 90% reduction by 2015 Total phase-out by 2020[c]	Freeze in 2016 at 2015 base level Total phase-out by 2040
Hydrobromofluorocarbons (HBFCs)	Phased out end of 1995	Phased out end of 1995
Methyl bromide (horticultural uses)	Freeze in 1995 at 1991 base level[d] 25% reduction by 1999 50% reduction by 2001 70% reduction by 2003 Total phase-out by 2005	Freeze in 2002 at average 1995–98 base level 20% reduction by 2005[e] Total phase-out by 2015
Bromochloromethane (BCM)	Phase-out by 2002	Phase-out by 2002

[a] With the exception of a very small number of internationally agreed essential uses that are considered critical to human health and/or laboratory and analytical procedures
[b] Based on 1989 HCFC consumption with an extra allowance (ODP weighted) equal to 2.8% of 1989 CFC consumption
[c] Up to 0.5% of base level consumption can be used until 2030 for servicing existing equipment.
[d] All reductions include an exemption for pre-shipment and quarantine uses.
[e] Review in 2003 to decide on interim further reductions beyond 2005

Source: EA 2003a

The timetable set by the Montreal Protocol applies to bulk consumption of ODSs. Consumption is defined as the quantities manufactured or imported, less those quantities exported in any given year. Percentage reductions relate to the designated 'base year' for the substance. The Montreal Protocol does not forbid the use of existing or recycled controlled substances beyond the phase-out dates (EA 2003a).

Concentrations of ODSs have begun to decrease (see figure 3.9), leading towards the stabilisation of the ozone layer, which is predicted to recover to its pre-1980 levels by 2050. However, constant production of ODSs at the 1999 rate would extend the time for the ozone layer to recover to beyond 2100 (WMO 2002).

Ultraviolet radiation in Brisbane

Sunlight contains damaging ultraviolet (UV) radiation—light in the range of 100–400 nanometres (nm). Much of this UV radiation (and virtually all of the highly dangerous 100–290 nm wavelengths) is absorbed by the atmosphere, initially by the stratospheric ozone layer, and subsequently by clouds (and other aerosols). The amount of UV radiation reaching the ground depends on the both the angle of the Sun (which varies with latitude, season and time of day) and atmospheric attenuation (which varies with stratospheric ozone levels, cloud cover and altitude). Due to Queensland's location in the lower latitudes, Queenslanders are exposed to higher levels of UV radiation than many of their interstate counterparts.

The Australian Radiation Protection and Nuclear Safety Agency measures UV levels in large population centres around Australia. It presents the data in terms of the World Health Organization's Global Solar UV Index, which is based on the highest level of UV measured during the day (typically around the solar noon). Each unit in the index equates to 25 milliWatts/m² of UV radiation at the Earth's surface for UV wavelengths between 290 and 400 nm. UV index levels below 2 are regarded as low, while index levels above 11 are regarded as extreme.

Over the period 1996–2002, UV index levels in Brisbane were generally classed as moderate in May to August, high in April and September, very high in March, October and November, and extreme in December, January and February.

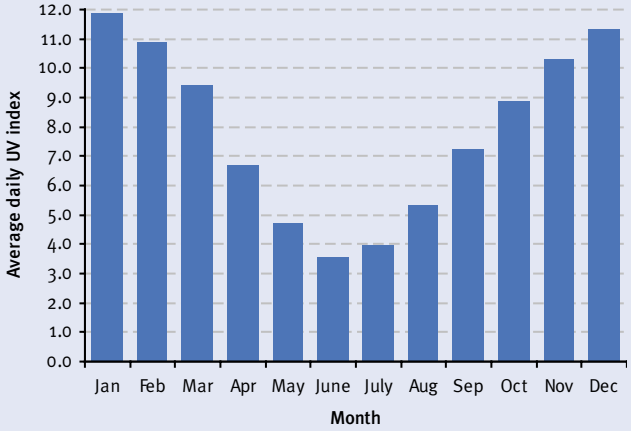


Figure 3.11 *Average maximum UV levels, Brisbane, 1996–2002*
Source: Dr John Javorniczky, Australian Radiation Protection and Nuclear Safety Agency

The Multilateral Fund was established under the Montreal Protocol in 1991 to assist and support developing countries transferring to ozone-friendly technologies. Australia contributes to the Multilateral Fund through AusAID, is a member of the committee that manages the fund, and also undertakes bilateral projects in developing countries.

Australia has national and state legislation to implement the provisions of the Montreal Protocol. The Commonwealth's *Ozone Protection Act 1989* regulates the phase-out of ODSs in Australia, usually well ahead of the schedules set out in the Montreal Protocol. It controls the manufacture, import and export of ODSs through a licensing system. Three types of licences (essential uses, controlled substances, and used substances) are issued to approved applicants for a two-year period subject to conditions (for example, the licensee may import listed substances only from a country that is a party to the Montreal Protocol). Licence and activity fees pay for costs associated with the phase-out of ODSs.

The Ozone Protection Strategy, developed by all levels of government, industry and the community, was agreed in 1989 and revised in 1994. It sets out a program of actions for government and industry to minimise emissions of ODSs and to coordinate their phase-out in Australia.

The use of methyl bromide (an agricultural and building fumigant) will be phased out in Australia (with the exception of any exemptions) by January 2005. Environment Australia is currently finalising a national strategy for the management and phasing-out of methyl bromide.

CFCs are being phased out of use and HCFCs are being used as refrigerants and solvents in their place as an interim arrangement. The import, manufacturing and export of HCFCs are controlled through the licensing system operated by Environment Australia.

The Australian states and territories regulate the supply, sale and use of ODSs. In Queensland, the *Environmental Protection Act 1994* and the *Environmental Protection Regulation 1998* control the use of ODSs, the use of equipment using ODSs, and the labelling of ODSs and equipment that uses these substances (for example, car air-conditioning units and refrigerators), and ensure that those who service equipment containing these substances are properly trained and accredited.

The Australian Halon Management Strategy was developed in 2000 by the Commonwealth Government in cooperation with state and territory governments, industry and environmental groups. It outlines how Australia will meet its obligations under the Montreal Protocol to manage stocks of halons up to 2030 and until the complete phase-out of Australian halon stocks can be achieved. Halons are used in specialised fire protection equipment and systems used in defence, aviation and shipping. Until a suitable alternative can be found, the Commonwealth has established the National Halon Bank for the management of stocks of halons to meet Australia's needs and to manage Australian halon stocks and those of other countries in our region, if required.

Photochemical smog

Summary

Photochemical smog is generated in a region under particular meteorological and environmental conditions. While weather conditions cannot be controlled, pollution forecasts and emission reduction and management strategies for key pollutant sources can be used to limit the occurrence and severity of photochemical smog incidences.

Ozone is the major component of photochemical smog. On average, ozone levels in south-east Queensland exceeded the national ozone standard on one to two days a year over the past ten years. There is no discernible trend in ozone concentrations over this time because of the variations in the influencing conditions each year. Recent monitoring in Gladstone shows that ozone levels are well within the standard.

Description

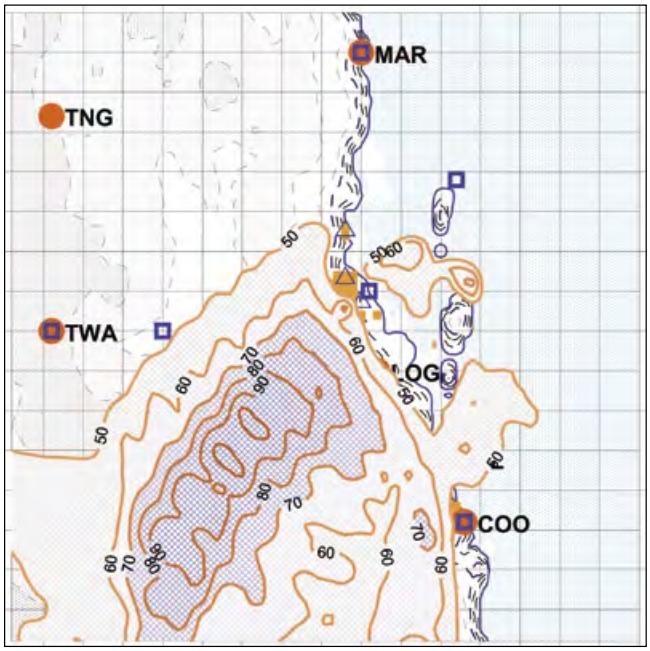
Photochemical smog is sometimes seen as a white haze in the sky, affecting the visual amenity of the region. The main components of photochemical smog are photochemical oxidants, primarily ozone. Ozone in the troposphere (at ground level) is due to anthropogenic emissions. While some ozone is generated by natural processes, chemical reactions between air pollutants can increase ozone levels under certain meteorological conditions (see 'Photochemical smog in south-east Queensland' on page 3.20). At elevated concentrations, ozone can affect our health, causing respiratory problems.

Ozone is known as a secondary pollutant because it is generated by reactions of other (primary) pollutants. Oxides of nitrogen (NO_x) and volatile organic compounds (VOCs) are the main precursors involved in the generation of ozone. Motor vehicles are the major anthropogenic source of NO_x and VOCs in most urban areas. VOC emissions from natural sources, including vegetation growth and burning, may be key contributors to photochemical smog events.

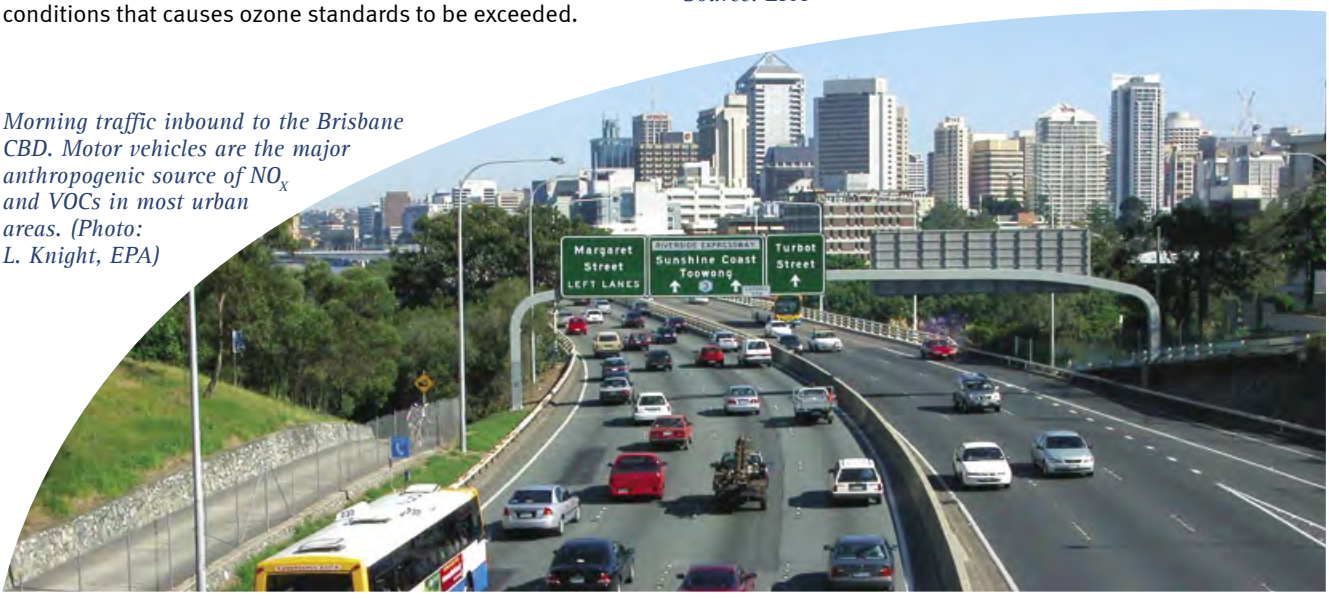
Reductions in emissions of the key sources that lead to photochemical smog are important to limit the occurrence of photochemical smog events; however, it is usually the combination of emissions with conducive weather conditions that causes ozone standards to be exceeded.

It can take several hours for photochemical reactions to take place and photochemical smog to form. Therefore, high ozone concentrations may occur downwind at areas remote from the actual sources of pollution. Wind patterns that recirculate pollution back to its source, to combine with newly generated emissions over the course of several days, are often associated with episodes of elevated photochemical smog levels in south-east Queensland.

An understanding of wind patterns, pollutant emissions, photochemical reactions and transportation of pollutants in a region is needed to ensure that sources of pollution are not located in areas where they will readily induce photochemical smog. The EPA and Brisbane City Council are developing an air quality modelling system for south-east Queensland to enable assessment of the impacts of pollutants on the generation of photochemical smog.



Air quality modelling can be used to predict ozone concentrations in south-east Queensland. Source: EPA



Morning traffic inbound to the Brisbane CBD. Motor vehicles are the major anthropogenic source of NO_x and VOCs in most urban areas. (Photo: L. Knight, EPA)

Pressures

A number of sources of the key pollutants that cause photochemical smog are anthropogenic and controllable (motor vehicle emissions, refinery emissions, power station emissions, controlled vegetation burns); other factors are natural and cannot be controlled (biogenic emissions from vegetation growth, bushfires and weather conditions).

Sources of NO_x and VOC emissions produce the precursors to photochemical smog. Table 3.6 shows the key sources of NO_x and VOC emissions in south-east Queensland in 2000. Motor vehicles are the main source of NO_x emissions, contributing just over 62%. Industry, mainly electricity generation, petroleum refining and manufacturing processes involving fuel combustion, is the next highest source of NO_x emissions, producing 15.9%. Motor vehicles are the highest anthropogenic source of VOCs, emitting 22% of VOCs across south-east Queensland. However, biogenic sources—the vegetation across the region—emit 61.2% of VOCs in south-east Queensland. This vegetation, particularly native species, plays an important role in regional ecosystems. Vegetation emits more VOCs during the hotter summer months, when strong sunlight is available to assist in the photochemical reactions.

Limiting motor vehicle emissions is difficult, as the vehicle kilometres travelled in south-east Queensland are expected to increase by up to 60% and may reach 34 200 million kilometres in 2011 (EPA 2003a). As the population of south-east Queensland continues to increase and live further away from the centre of the region, motor vehicle use and vehicle trip lengths are expected to increase. Other anthropogenic sources of NO_x, such as electricity generation, will also place more pressures on the air environment.

Table 3.6 Emission contributions to NO_x and VOCs from all sources in south-east Queensland, 2000

Source	NO_x (t)	NO_x (%)	VOCs (t)	VOCs (%)
Motor vehicles	60 579	62.2	83 167	22.0
Other mobile sources	9 104	9.3	5 550	1.5
Industry	15 450	15.9	15 092	4.0
Area-based sources*	365	0.4	21 266	5.6
Biogenic	7 622	7.8	231 507	61.2
Burning	4 265	4.4	21 684	5.7
Total	**97 385**	**100.0**	**378 266**	**100.0**

* Includes emissions from domestic and commercial sources, such as cigarette smoke.

Source: EPA 2003a

The burning of vegetation during bushfires, controlled burning programs or agricultural crop burning also produces NO_x and VOC emissions. Controlled or hazard-reduction burning programs and agricultural burning can be scheduled to coincide with weather conditions that allow the dispersion of pollutants. Bushfires, on the other hand, are random events that can be exacerbated by particular weather conditions. Uncontrollable factors, such as bushfires and weather conditions, along with sunlight, remain the key triggers for photochemical smog episodes in south-east Queensland.

Condition and trends

Ozone is monitored in south-east Queensland and Gladstone as an indicator of photochemical smog. The National Environment Protection (Ambient Air Quality) Measure (AIR NEPM) standards for ozone are 0.10 ppm averaged over one hour and 0.08 ppm averaged over four hours (the goal being that the standard is not exceeded on more than one day a year).

Monitoring began in Gladstone in 2000. No exceedences of the Air NEPM standards for ozone have been measured in Gladstone. Ozone levels in Gladstone reach half of the one-hour and four-hour standards on only a few days a year. Although a number of major industries in the Gladstone region emit considerable amounts of NO_x and VOCs, these emissions, coupled with prevailing weather conditions, do not appear to result in photochemical smog episodes downwind of the Gladstone sources.

The one-hour ozone standard has been exceeded in south-east Queensland at least one day a year in the past ten years, except for 2001 (figure 3.12). Figure 3.13 shows a similar pattern for the four-hour ozone standard. On average, ozone levels exceed the one-hour and four-hour standards on only one or two days each year.

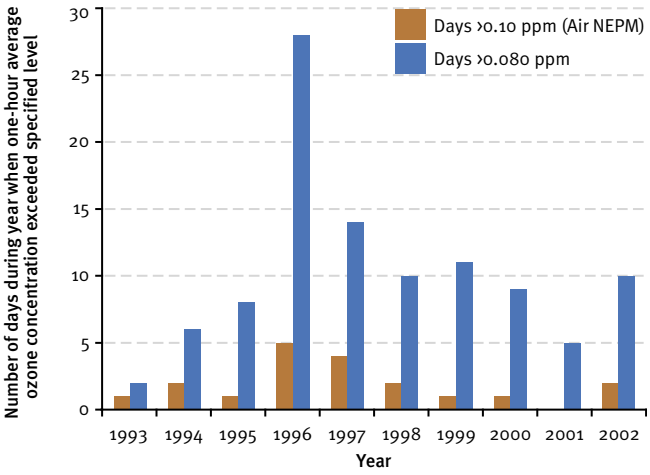


Figure 3.12 Regional trend in one-hour average ozone concentrations in south-east Queensland, 1993–2002

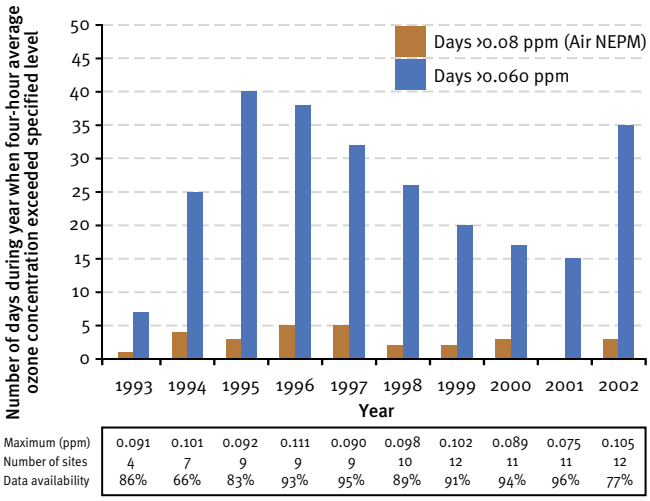


Figure 3.13 Regional trend in four-hour average ozone concentrations in south-east Queensland, 1993–2002

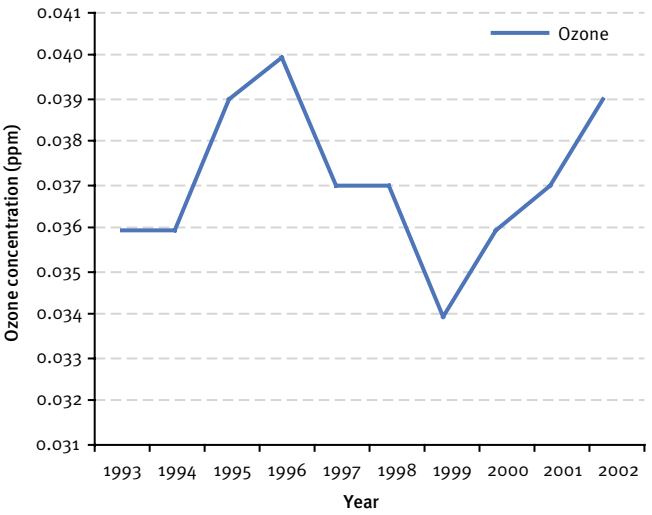


Figure 3.14 *Trend in 95th percentile one-hour ozone concentrations in south-east Queensland, 1993–2002*

The number of days on which ozone concentrations exceeded 0.08 ppm for one hour and 0.06 ppm for four hours appears to decrease from 1996 to 2001 but rises again in 2002. This trend is mirrored at most individual monitoring sites over the same period, and largely reflects bushfire activity in the respective years. Ozone concentrations in south-east Queensland are reported to vary from year to year, depending principally on weather conditions, with no definite trends over time.



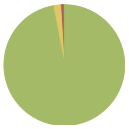
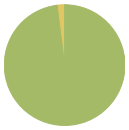
Weather conditions and vegetation burning from bushfires or controlled burns are the main contributors to elevated levels of ozone and the generation of photochemical smog in south-east Queensland. (Photo: QFRS)

Figure 3.14 shows yearly variations in the 95th percentile one-hour ozone concentrations at the Rocklea air monitoring site in south-east Queensland. The 95th percentile is the level that 95% of the measured data are below and gives a better indication of our everyday exposure to air pollution. Ozone concentrations are shown to be well below the 0.10 ppm value of the one-hour ozone standard.

Weather conditions influence both the extent of the vegetation burning and the incidence of bushfires, causing variations in the impact on air quality from year to year. Exceedences of the standards have almost always been associated with the presence of bushfires in the region (EPA 2003b). However, ozone exceedences measured at inner-city and outer south-east Queensland sites in March 1999 (when there was no evidence of bushfires in the region) have demonstrated that the level of emissions from everyday sources (motor vehicles, industry and domestic activities) can be sufficient to generate ozone levels that exceed the Air NEPM standards under certain meteorological conditions (EPA 2003b).

Summary of condition and trend indicators

Photochemical smog

Indicator	SEQ	Gladstone
Exceedences of Air NEPM standards for ozone (O_3)		

SEQ = South-east Queensland

Key to condition:

Good = the proportion of time that ambient levels were below 50% of the standard in 1999–2002

Moderate = the proportion of time that ambient levels were between 50% and 100% of the standard in 1999–2002

Poor = the proportion of time that ambient levels were above the standard in 1999–2002

Not Assessed

Responses

To limit ozone exceedences, the precursor pollutants (particularly NO_x and VOCs) need to be controlled at the source. Current strategies to limit and manage photochemical smog production are described below.

The joint Land Transport Environment Committee and National Environment Protection Council (NEPC) have proposed the introduction of Australian design rules (ADRs) that will result in tighter pollutant emission limits to offset the predicted increase in vehicle kilometres travelled. The future introduction of new petrol-fuelled cars adhering to ADR 37/01, ADR 79/00 and ADR 79/01 is predicted to reduce evaporative VOC emissions from the south-east Queensland motor vehicle fleet by between 25% and 40% by 2011, depending on the population, vehicle travel and employment scenarios. Reductions in NO_x emissions from motor vehicles may also occur by 2011, but the tighter vehicle emission limits may be counterbalanced by the increased vehicle travel predicted for the region (EPA 2003a).

Public transport initiatives, such as the AirTrain, TravelSmart and South East and Inner Northern Busways, are now operating in south-east Queensland to reduce private motor vehicle travel and to encourage the use of public transport to limit emissions of pollutants such as NO_x.



More public transport options, including the AirTrain to and from the Brisbane international and domestic airports, are available in south-east Queensland to reduce our use of private motor vehicles. (Photo: BCC)

The EPA is currently working on the development of a regulatory impact statement on vapour recovery of VOCs at industrial facilities that may release significant fugitive VOC emissions.

Brisbane City Council and the EPA have been working together on the South-east Queensland Airshed Study. The Air Emissions Inventory for the South-East Queensland Region was released in April 2003. It provides an estimate of air pollutant emissions from motor vehicles, natural sources, industry, and commercial and domestic sources. The inventory will be used in the south-east Queensland air quality modelling system currently being developed. The modelling system will be used to understand how pollution is generated, dispersed and distributed around the region. It will be able to model different planning scenarios to assess the best locations for pollution sources to limit the possibility of photochemical smog formation; it will also provide further information on the impacts of proposals for changes to influencing factors, such as the fuel quality of motor vehicles.

Local and regional strategies are targeting pollutant sources that lead to photochemical smog. Brisbane City Council's Brisbane Air Quality Strategy and the South East Queensland Regional Air Quality Strategy, led by the EPA, include actions intended to limit photochemical smog events, such as reducing key sources of pollution and conducting further research into the causes of photochemical smog events in south-east Queensland. In the early 1990s the EPA expanded its ozone monitoring network to collect additional information on the concentrations and transport of photochemical smog in south-east Queensland.

In recent years the EPA and the agencies responsible for hazard-reduction burning in south-east Queensland have sought to better coordinate these activities with meteorological conditions that will disperse the resulting emissions to reduce the potential for photochemical smog events to occur in the region.

Photochemical smog in south-east Queensland

Photochemical smog is formed when volatile organic compounds (VOCs) and nitrogen oxides (NO_x) react in the presence of sunlight, forming a complex mixture of pollutants. The major constituents of photochemical smog are photochemical oxidants, most commonly ozone (O_3), and some suspended particles.

The haze caused by photochemical smog can reduce visibility. Photochemical smog is generally limited by the amount of sunlight available or the amount of NO_x present. The amount of NO_x influences the total amount of ozone produced, while VOCs and sunlight influence the rate at which it is produced.

The precursors to photochemical smog formation generally arise from combustion (fuel-burning) sources such as motor vehicles, power stations and industrial facilities using combustion processes. Motor vehicles are generally the major source of NO_x in urban areas. Biogenic emissions from vegetation are significant sources of VOCs.

The reactions that produce photochemical smog occur over several hours, and during this time polluted air can be transported by the wind to areas remote from the source. This can result in rural areas far from an urban source being exposed to the highest levels of pollutants. For this reason, the EPA's south-east Queensland network of air quality monitoring stations conducts ozone monitoring at inland rural locations.

Ozone has the potential to affect human health by reducing lung function and aggravating pre-existing diseases such as asthma, and can contribute to premature mortality. It can accelerate the ageing of materials such as rubber and some plastics, and is toxic to many plants. The major effect in plants is leaf injury, but crops can have decreased yields and growth rates of tree seedlings can be reduced without visible injury.

Researchers believe that Brisbane, along with Perth, has one of the highest potentials for smog of Australia's cities (AATSE 1997). This smog potential is the result of several factors:

- the south-east Queensland airshed is a basin shape, surrounded by inland mountains;
- the airshed's location results in many hours of sunshine and many days with little or no wind;
- in early spring and late autumn Brisbane has relatively high daytime temperatures, which coincide with land management and controlled vegetation burning seasons;
- south-east Queensland has extensive vegetation cover, resulting in high levels of biogenic emissions of VOCs;
- local wind patterns often result in the recirculation of pollutants in the airshed rather than dispersion out to sea; and
- south-east Queensland continues to attract more people, who travel longer distances in motor vehicles, adding to NO_x and VOC emissions in the region. Ozone can affect large areas of an airshed and it therefore is regarded as a regional problem, although impacts can be localised. As a consequence, reducing emissions of photochemical smog precursors, NO_x and VOCs, is a priority for regional air quality.

View of Brisbane from Mount Gravatt during a pollution episode on 23 June 2002 (Photo: EPA)



Particle pollution and reduced visibility

Summary

Particles are emitted into the atmosphere from a variety of sources, including motor vehicles and industrial activities. However, climatic conditions and the contribution of smoke from bushfires, agricultural burning and hazard-reduction burning have the most significant impact on particle levels and cause variations from year to year. Particles emitted to the atmosphere can contribute to a range of health and amenity impacts, including respiratory diseases and reduced visibility (see Glossary for descriptions of pollutants and their effects). EPA monitoring in south-east Queensland, Gladstone, Rockhampton, Mackay and Townsville has shown that particle concentrations seldom exceed national health-based air quality standards under normal conditions. Exceedences of standards are usually associated with extreme events such as bushfires or dust storms.

A build-up of airborne particles can obscure visibility. The *Environmental Protection (Air) Policy 1997* provides a guideline for visual amenity that is exceeded at times in all regions where monitoring takes place (south-east Queensland, Gladstone and Mackay) as a result of smoke from bushfires, controlled burning and agricultural practices.

Description

Airborne particles are produced through natural processes and human activities. Because Australia is such a dry continent, its atmosphere contains a significant amount of particulate matter in the form of windblown dust. Bushfires, hazard-reduction burning in forests and agricultural practices also introduce particles to the atmosphere. In industrial and urban areas, the combustion of fossil fuels (by power stations, petroleum refineries and motor vehicles) and commercial operations contributes to airborne particle levels. Agricultural, mining and quarrying activities can contribute particle emissions. In coastal areas, the atmosphere can contain a significant level of sea-salt particles.

Airborne particles vary considerably in size, from less than 1 micrometre (µm) in diameter (small enough to remain suspended in the atmosphere almost indefinitely) to more than 50 µm in diameter. These larger particles tend to settle out rapidly under the influence of gravity. Smaller particles (less than 10 µm in diameter, known as PM_{10}) are considered a concern to human health. An increasing body of evidence suggests that, of the total PM_{10} fraction, the fraction less than 2.5 µm ($PM_{2.5}$) may be the major area of concern in terms of adverse effects on human health (NEPC 2002).

Apart from affecting human health, airborne particles can build up in the atmosphere, obscuring visibility. Smoke from vegetation burning that occurs throughout the state is the most common contributor to events of high concentrations of fine particles; these events occur most frequently when stable meteorological conditions do not allow the smoke to be dispersed (EPA 2001a). State government agencies are working together to limit the air quality impact of planned hazard-reduction burns by coordinating burning with more suitable weather conditions. Bushfires remain a significant and unpredictable source of fine-particle pollution in Queensland.

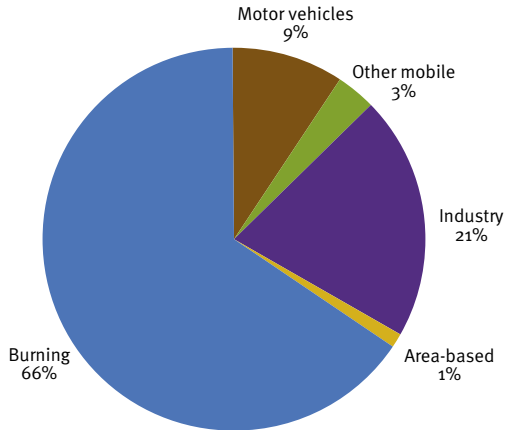
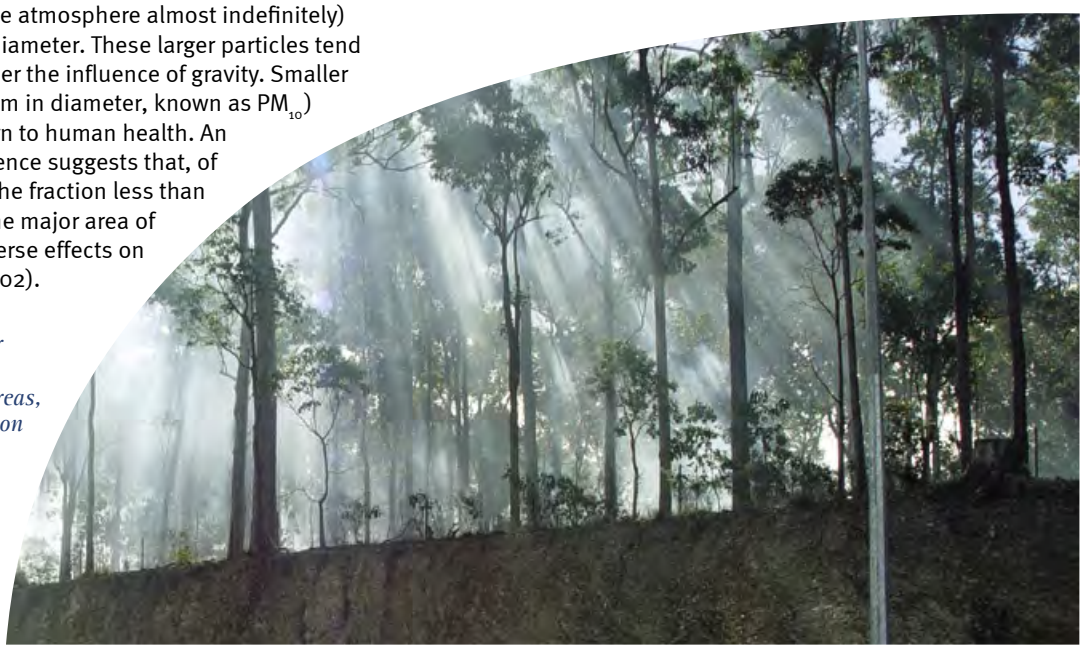


Figure 3.15 *PM_{10} emissions in south-east Queensland, 2000*
Source: EPA 2003a

While sources such as motor vehicles and industry usually contribute consistent amounts of particles to the atmosphere each day, vegetation burning events are sporadic and can contribute significant emissions over a few days or on only one day. Episodes of reduced visibility that cause exceedences of the air quality particle standards are usually triggered by vegetation burning, such as bushfires. Vegetation burning is estimated to have contributed about two-thirds of the PM_{10} emissions in south-east Queensland in 2000 (figure 3.15).



Smoke from bushfires or controlled burns can be blown into residential areas, depending on the direction of the wind, and under stable meteorological conditions may stay suspended in the air, reducing visibility until the smoke particles disperse. (Photo: QFRS)

Smoke from the burning of vegetation—bushfires, controlled hazard-reduction burns, or burns for agricultural purposes (such as harvesting of sugarcane)—is the most significant cause of low-visibility events across Queensland. Stagnant, stable meteorological conditions mean that whatever pollution is emitted into the atmosphere cannot be dispersed. This leads to a build-up of particulate matter in the atmosphere and elevated pollution levels in the region until weather conditions change and the pollution can be dispersed. Such stable conditions occur most frequently in winter and early spring, particularly during the night or early morning. These seasons are also the optimal time of year to conduct controlled burning to reduce fuel loads and the risk of bushfires in the lead-up to summer. Most exceedences of the visibility and particle air quality standards occur as a result of vegetation-burning activities undertaken under weather conditions that limit dispersion.

Although all sources of particle pollution are being targeted to reduce emissions, the best way to reduce low-visibility events is to better manage vegetation burning (including bushfires, agricultural burning and controlled burning). In the case of bushfires, however, this is difficult to achieve and they are the dominant cause of haze during late winter and early spring.

Pressures

The particle pollution that affects air quality is derived from a variety of sources (figure 3.15). Population and economic growth in Queensland has increased the use of transport and the development of industries, creating more particle pollution and pressure on the air environment. Some of this growth can be managed through urban planning and improved industrial and motor vehicle technologies to limit the environmental impacts. Overall, added particle emissions from vegetation burning induce the low visibility and elevated particle levels that lead to exceedences of air quality particle standards.

While those responsible for controlled burning and agricultural fires plan to conduct any necessary burns under weather conditions that will disperse the smoke from the fires as quickly as possible, this is not always successful or possible. The nature of bushfires means that they can occur at any time and the degree of their effect on visibility and particle pollution depends on the conditions existing when the bushfire occurs. In 2000, the majority of vegetation burning in south-east Queensland was attributed to bushfires (97%); controlled burning (2%) and agricultural burning (1%) contributed only a small amount of particle emissions by comparison (table 3.7). South-east Queensland's unusually severe bushfire season in 2000 resulted in PM_{10} emissions much higher than those in a typical year.

Table 3.7 Sources of particle emissions as PM_{10} in south-east Queensland, 2000

Source	PM_{10} emissions (t)
Controlled burning	380
Bushfires	15 150
Agricultural burning	110
Total vegetation burning	**15 640**
Motor vehicles	2 250
Other mobile sources	830
Industry	4 900
Area-based sources	290
Total	**23 910**

Source: EPA 2003a

Condition and trends

Visibility is measured at air quality monitoring stations in south-east Queensland, Gladstone and Mackay. PM_{10} monitoring is undertaken in south-east Queensland, Gladstone, Mackay, Rockhampton and Townsville. $PM_{2.5}$ monitoring also occurs in south-east Queensland. Table 3.8 shows which pollutants are measured at EPA air quality monitoring sites in Queensland.



Controlled burning (pictured) and agricultural burning contributed only a small amount of particle emissions during the severe bushfire season in south-east Queensland in 2000. (Photo: QFRS)

Table 3.8 Air quality monitoring network operated by the EPA at December 2002

Monitoring site	Air quality monitoring equipment													Meteorological equipment				
	Ozone	Photochemical smog parameters, Rsmog[a]	Carbon monoxide	Nitrogen oxides	Sulfur dioxide	Visibility-reducing particulate matter (light scatter)	PM_{10} Hi Vol[b]	PM_{10} TEOM[c]	$PM_{2.5}$	TSP	BTX[d]	Wind speed	Wind direction	Air temperature	Humidity	Solar radiation	Rainfall	Vertical wind
Southern Region																		
Mountain Creek	✓			✓		✓		✓				✓	✓	✓				
Deception Bay	✓			✓								✓	✓					
Eagle Farm	✓			✓	✓	✓	✓	✓				✓	✓	✓	✓			
Brisbane CBD	✓		✓	✓	✓	✓		✓	✓		✓	✓	✓					
South Brisbane			✓	✓				✓				✓	✓	✓				
Woolloongabba			✓				✓	✓		✓		✓	✓					
Rocklea	✓	✓		✓		✓	✓	✓	✓			✓	✓	✓	✓	✓	✓	
Springwood	✓			✓	✓			✓	✓		✓	✓	✓	✓				
North Maclean	✓			✓								✓	✓					
Flinders View	✓			✓	✓	✓		✓				✓	✓	✓	✓			
Mutdapilly	✓			✓								✓	✓					
Gatton												✓	✓	✓				
Central Region																		
Targinie (Stupkin Lane)	✓			✓	✓	✓		✓			✓	✓	✓	✓				
Targinie (Swans Rd)				✓	✓	✓						✓	✓					
Ticor Hill				✓	✓							✓	✓					✓
Mount Miller				✓	✓							✓	✓					✓
Barney Point, Gladstone				✓	✓	✓	✓					✓	✓	✓	✓	✓		
South Gladstone				✓				✓				✓	✓					
Clinton, Gladstone				✓	✓		✓	✓				✓	✓					
Aldoga												✓	✓					
Rockhampton							✓					✓	✓					
Mackay						✓		✓				✓	✓					
Northern Region																		
Townsville Port								✓				✓	✓					
South Townsville							✓											
Garbutt, Townsville							✓											
Stuart, Townsville					✓								✓	✓				
Mount Isa					✓								✓	✓				

[a]Rsmog = smog reactivity; [b]Hi Vol = high volume sampler; [c]TEOM = tapered element oscillating microbalance sampler; BTX[d] = benzene, toluene or xylenes

The visibility and particle concentrations measured in Queensland are evaluated against the goals in Queensland's *Environmental Protection (Air) Policy 1997* (Air EPP) and the standards in Australia's *National Environment Protection (Ambient Air Quality) Measure 1998* (Air NEPM). The Air EPP air quality goal of 20 km visibility is intended to protect the visual amenity of a region, a feature that many people value highly. No human health effects are linked directly with this visibility goal. The Air NEPM standard for PM_{10} (50 µg/m³ for 1 day) is set to provide adequate protection of human health and wellbeing. Five exceedences of the PM_{10} standard are allowed each year. In 2003 the NEPC set advisory standards for $PM_{2.5}$ of 25 µg/m³ (1 day) and 8 µg/m³ (1 year). Table 3.9 shows the Air NEPM standards.

Table 3.9 National Environment Protection (Ambient Air Quality) Measure air quality standards and goals

Pollutant	Averaging period	Maximum concentration	Goal within 10 years Maximum allowable exceedences
Carbon monoxide	8 hours	9.0 ppm	1 day a year
Nitrogen dioxide	1 hour 1 year	0.12 ppm 0.03 ppm	1 day a year none
Photochemical oxidants (as ozone)	1 hour 4 hours	0.10 ppm 0.08 ppm	1 day a year 1 day a year
Sulfur dioxide	1 hour 1 day 1 year	0.20 ppm 0.08 ppm 0.02 ppm	1 day a year 1 day a year none
Lead	1 year	0.50 µg/m³	none
Particles as PM_{10}	1 day	50 µg/m³	5 days a year
Particles as $PM_{2.5}$	1 day 1 year	25 µg/m³ 8 µg/m³	

Source: NEPC 1998

Particles as PM_{10} and $PM_{2.5}$

PM_{10}

Since 1993 the EPA has been upgrading its PM_{10} sampling equipment from devices that sample one day in every six to continuous monitoring equipment. All PM_{10} air quality monitoring sites in south-east Queensland, most sites in the Gladstone region and the Mackay site are now equipped with the continuous monitoring equipment. The EPA intends to upgrade the remaining PM_{10} equipment in the rest of the state in coming years. Since 1999, the EPA has begun monitoring PM_{10} at South Gladstone and Targinie in Gladstone, and on the Sunshine Coast in south-east Queensland. The EPA is collecting PM_{10} data at additional monitoring stations at Townsville, in partnership with the Townsville Port Authority, and at South Brisbane, in partnership with the Department of Main Roads.

Figure 3.16 shows how often the Air NEPM standard for PM_{10} has been exceeded throughout Queensland since 1993. With the exception of 1994, 2000 and 2002, PM_{10} levels in all regions seldom exceeded the Air NEPM standard in the past ten years. Below-average rainfall was experienced along much of Queensland's east coast in recent years, contributing to higher levels of windblown dust in all regions where monitoring took place (see 'Visible effects of a dust storm', page 3.29). The impact of bushfires in south-east Queensland and in the Gladstone region, and more extensive cane burning in the Mackay region, can be seen in the increase in frequency of days when PM_{10} exceeded the Air NEPM PM_{10} standard of 50 µg/m³ in Mackay (1999–2002), south-east Queensland (2000 and 2002) and Gladstone (2001 and 2002).

Dust storms in July and October 2002 added to the number of days when exceedences were measured in all regions across the state. Particles from extensive bushfires occurring in New South Wales in December 2002 were transported up the Queensland coast by south-easterly winds and caused elevated PM_{10} levels in south-east Queensland and Gladstone (EPA 2003c).

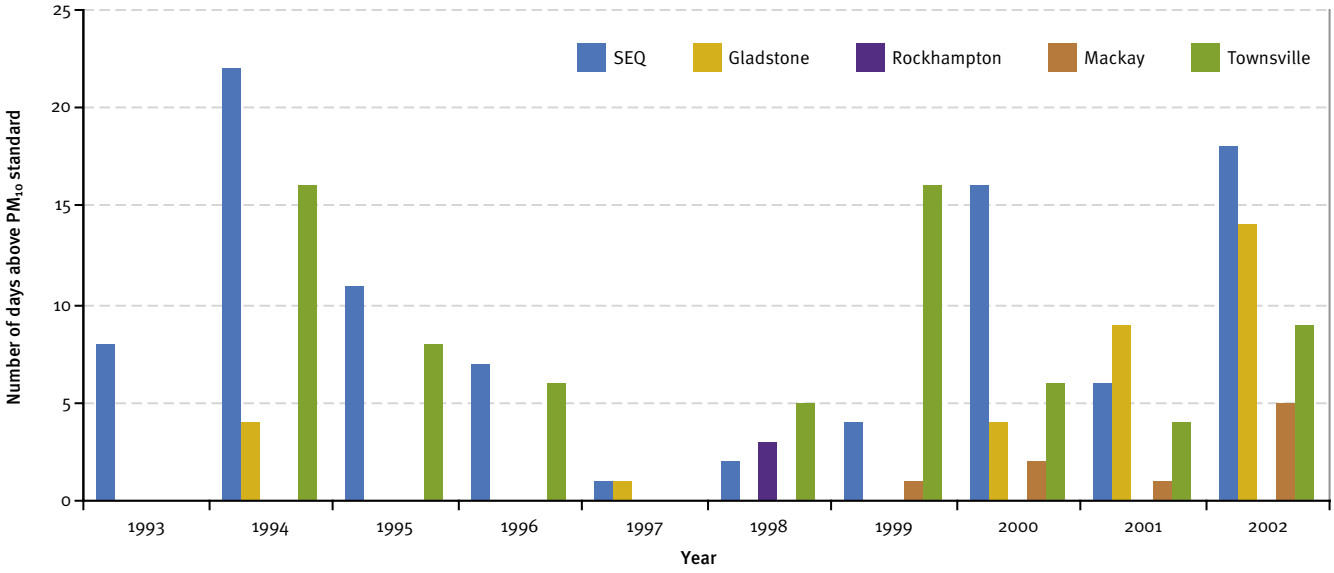


Figure 3.16 *Regional PM_{10} exceedences, 1993–2002*

In general, south-east Queensland PM_{10} levels have remained fairly static since 1993. Dry conditions and an increased incidence of bushfires and hazard-reduction burning were responsible for higher levels of PM_{10} in 1994–96 and again in 2000 and 2002, when smoke from bushfires (2000) and windblown dust (2002) were the main sources of elevated PM_{10} levels.

The general trend in PM_{10} levels at sites in Gladstone, Rockhampton and Townsville has been downward since monitoring began in these regions. However, dry conditions and smoke particles from bushfires led to a rise in levels in Gladstone in 2001 and 2002, causing an exceedence of the Air NEPM standard. Dry conditions were also responsible for increases in the levels of PM_{10} at Rockhampton (2001) and Townsville sites (2001 and 2002), explaining the exceedences of the standard in Townsville shown in figure 3.16.

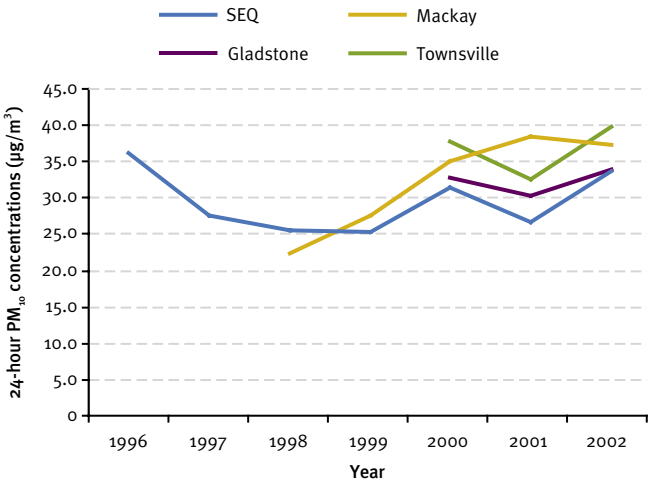


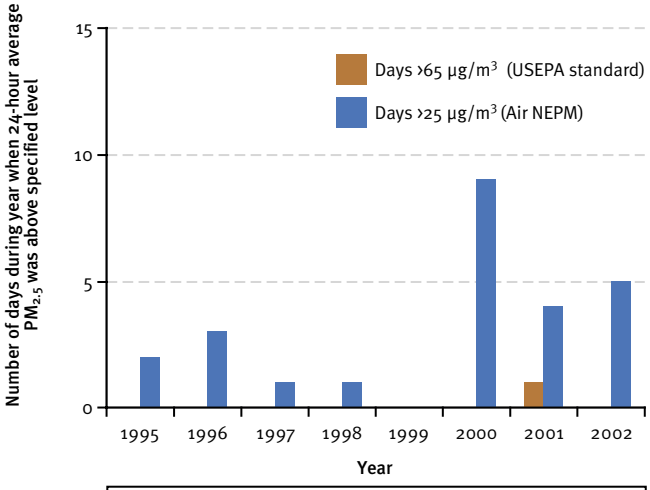
Figure 3.17 *Regional trends in 95th percentiles for 24-hour PM_{10} concentrations, 1996–2002*

PM_{10} levels at West Mackay have risen since monitoring began in 1998 due to the increased amount of cane burning during the 1999 and 2000 harvesting seasons and greater levels of windblown dust generated by the dry conditions experienced in 2001 and 2002.

Figure 3.17 shows yearly variations in the 95th percentile 24-hour PM_{10} concentrations at monitoring sites across Queensland's regions. The 95th percentile is the level that 95% of the measured data are below and gives a better indication of our everyday exposure to air pollution. It shows that exceedences are infrequent and levels are normally below the 50 µg/m³ standard.

$PM_{2.5}$

Currently $PM_{2.5}$ monitoring is conducted only in south-east Queensland. $PM_{2.5}$ levels in that region have exceeded the Air NEPM advisory standard for $PM_{2.5}$ (1 day), 25 µg/m³, on a number of occasions since monitoring began in 1995 (figure 3.18). The highest $PM_{2.5}$ level was recorded in 2001 and occurred as a result of particles generated by bushfires near the air monitoring station. Since 1995, $PM_{2.5}$ levels have varied considerably from year to year, with no clear trends emerging (EPA 2003c).



	1995	1996	1997	1998	1999	2000	2001	2002
Maximum (µg/m³)	53.7	42.5	42.0	27.0	21.3	37.4	100.6	47.3
Number of sites	2	2	2	2	3	3	3	3
Data availability	76%	97%	100%	84%	88%	97.6%	97.0%	96.3%

Figure 3.18 *Regional trend in 24-hour $PM_{2.5}$ concentrations in south-east Queensland, 1995–2002*

Emissions of $PM_{2.5}$ from sources such as motor vehicles and industrial processes remain fairly constant each day in south-east Queensland. Domestic wood burning is a winter source of particles and cause of reduced visibility. Sporadic sources, such as vegetation burning, tend to generate the extra emissions that lead to elevated levels of $PM_{2.5}$ particles in the atmosphere.

The occurrence and severity of vegetation burning events over a particular year can vary, depending on conditions. Figure 3.18 shows how often the $PM_{2.5}$ concentration exceeded the Air NEPM advisory standard each year during the period 1995–2002. Extensive bushfires caused exceedences of the standard in south-east Queensland in 2000 (9 days), 2001 (4 days) and 2002 (4 days). Other factors, such as dry conditions, can also contribute to higher levels of $PM_{2.5}$ from windblown dust.

The first time since measurements began in 1995 that $PM_{2.5}$ concentrations above the standard were not associated with bushfires or hazard-reduction burning was during the dust storm across eastern Australia in October 2002. The dust storm led to an increase in $PM_{2.5}$ levels in south-east Queensland for a number of days as the fine particles remained in the air before settling or being dispersed by the wind.



The 29 October 2003 dust storm obscured the view of Brisbane's CBD from Mt Coot-tha. (Photo: S. Torr, EPA)

Visibility

South-east Queensland

In south-east Queensland, low-visibility days are more frequent during late winter and early spring, when cooler conditions limit dispersion and hazard-reduction burning is more frequent. Figure 3.19 shows the dominance of the effects of bushfires on visibility in south-east Queensland. Days when visibility is less than 5 km (Days <5 km) are days of very poor air quality.

A higher frequency of low-visibility days has been associated with the periods 1993–97 and 2000–01, when dry conditions were responsible for an increased incidence of bushfires, and more extensive hazard-reduction burning of bushland was required to reduce the risk of major fire outbreaks. Bushfires were responsible for the rise in the incidence of low-visibility days in 2000 and 2001.

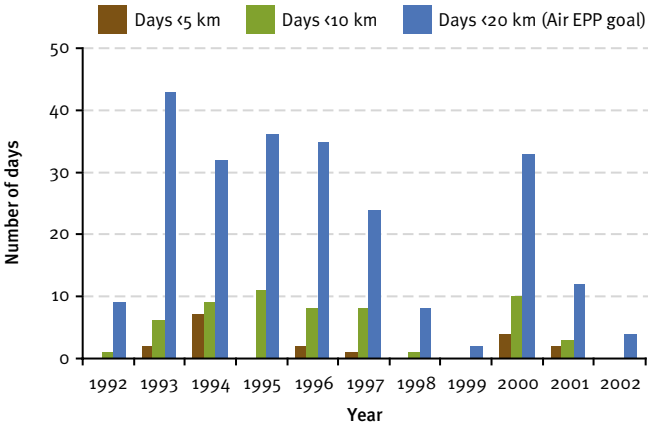


Figure 3.19 *Visibility in south-east Queensland, 1992–2002*

Gladstone region

The Gladstone region experiences significantly fewer days with low visibility than south-east Queensland (EPA 2001a). Although visibility-reducing particles are emitted by a number of industrial sources in the region, most particulate matter is released from tall stacks, reducing the ground-level impacts on Gladstone residents. Smoke from bushfires and hazard-reduction burning is the major cause of low-visibility days in the region. Bushfires resulting from dry conditions in 1993–95, and again in 2000–02, increased the number of days of reduced visibility in these years (figure 3.20). Over the decade, most low-visibility episodes occurred in the rural areas north-west of the city, which are surrounded by bushland (EPA 2001a).

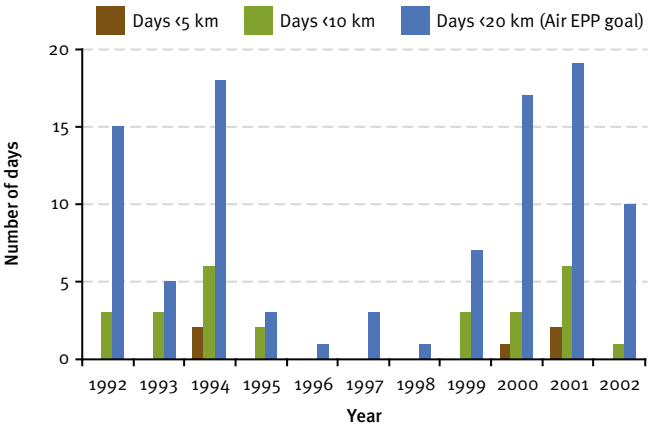


Figure 3.20 *Visibility in Gladstone, 1992–2002*

Mackay

The major cause of reduced visibility in the Mackay region is smoke generated by the burning of sugarcane or cane trash in the Pioneer Valley west of Mackay during the harvesting season, from June to December each year (EPA 2001a).

In 1999 and 2000 more cane burning than usual was carried out because of the relatively large amount of 'stand-over cane' being harvested. Stand-over cane is cane that was not harvested in the previous season. This increased burning is reflected in an increase in the number of days on which the Air EPP visibility goal was exceeded in 1999 and 2000 (figure 3.21). The amount of cane harvested in 2001 was lower than usual: the effects of previous poor seasons resulted in a curtailed harvesting season (and less cane burning) and, as a result, fewer low-visibility days. In 2002, bushfires and the impact of the dust storm in October were also causes of low-visibility days for the Mackay region.

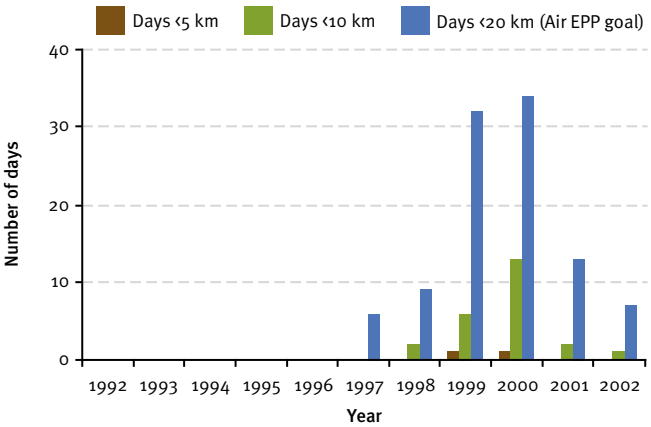
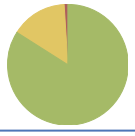
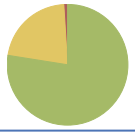
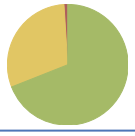
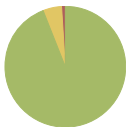
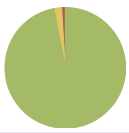
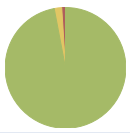


Figure 3.21 *Visibility in Mackay, 1992–2002*

Summary of condition and trend indicators

Particles and visibility

Indicator	SEQ	Gladstone	Rockhampton	Mackay	Townsville	Mount Isa
Exceedences of Air NEPM standard for PM_{10}						
Exceedences of Air NEPM advisory standard for $PM_{2.5}$						
Exceedences of Air EPP visibility goal						

Key to condition:

Good = the proportion of time that ambient levels were below 50% of the standard in 1999–2002

Moderate = the proportion of time that ambient levels were between 50% and 100% of the standard in 1999–2002

Poor = the proportion of time that ambient levels were above the standard in 1999–2002

Responses

The South-East Queensland Regional Air Quality Strategy (SEQRAQS) is led by the EPA and supported by local governments, other state government departments, industry and environmental groups with an interest in air quality management (EPA 1999b). One of the priorities of SEQRAQS is to achieve reductions in the levels of PM_{10} and $PM_{2.5}$ particles. Another priority is to improve understanding of the sources and impacts of these particles. Improvements in the coordination of hazard-reduction burning have reduced the number of days when it was the cause of reduced visibility or an exceedence of the air quality standard.

In recent years the EPA and the agencies responsible for hazard-reduction burning in south-east Queensland have sought to better coordinate these activities with meteorological conditions that will disperse the resulting smoke. Their efforts have been effective, as shown by the fact that, of a total of 55 days of reduced visibility, smoke from hazard-reduction burning was responsible for only four days of low visibility in the period 1998–2001.

Brisbane City Council's Draft Brisbane Air Quality Strategy (BCC 2001) aims to reduce particle pollution within the city by better managing controlled and domestic burning, and reducing industry and vehicle emissions. Brisbane City Council and other local governments incorporate air quality management into their local planning schemes when assessing industrial applications and planning new residential areas.



(Photo: QFRS)



Cane burnt during the harvesting season increases particle concentrations in the atmosphere. Green cane harvesting helps to reduce the amount of cane burning and the smoke emitted in the cane harvesting process.
(Photos: E. Taylor, EPA, main photo; QFRS, inset)

Controlled burning being undertaken at North Stradbroke Island in August 2001 (Photo: QFRS)

Particle pollution and reduced visibility

Smoke from the burning of sugarcane is the major cause of reduced visibility in the Mackay region. The cane industry is implementing new techniques and experimenting with new varieties to limit the amount of burning and smoke generated during the harvesting season. Each year since 1996, 80–90% of cane in the region has been cut using green cane harvesting techniques, reducing the amount of cane that is burnt. However, some of the Mackay region's canegrowing area has heavy clay soils, where green cane harvesting techniques are not suitable. There is also an ongoing need for some post-harvest burning of the residual cane trash for a number of reasons, including disease control, prevention of waterlogging of soils and replanting of new cane. It is not possible to eliminate cane burning (and its impact on visibility) in the Mackay region, but the cane industry is continuing to look into techniques and alternatives to further reduce the amount of burning necessary.

Transport, particularly motor vehicles, is a significant contributor to fine particle (PM_{10}) pollution in urban areas of Queensland. A number of strategies are in place to manage and reduce particle pollution from transport sources.

Emissions of fine particles from Australia's growing diesel vehicle fleet and their effect on health and visibility have become an issue of concern in recent years. In south-east Queensland, diesel vehicles travel 10% of all motor vehicle kilometres but account for 75% of PM_{10} emissions from motor vehicles (EPA 2003a). Since 1996 diesel vehicle emission standards in the Australian design rules (ADRs) have placed limits on the emission of particles for new vehicles. Australia is currently developing legislation to amend its ADRs for diesel vehicle emissions that will bring about the introduction of tighter standards. In 2001 the NEPC made the National Environment Protection (Diesel Vehicle Emissions) Measure (Diesel Vehicles NEPM). The Diesel Vehicles NEPM provides states with a framework for the management of emissions from their in-service diesel fleet (NEPC 2001b). The new diesel fuel standards set lower sulfur content for diesel fuels and are designed to allow the introduction of tighter European standards for diesel vehicle emissions, which will reduce particle emissions.

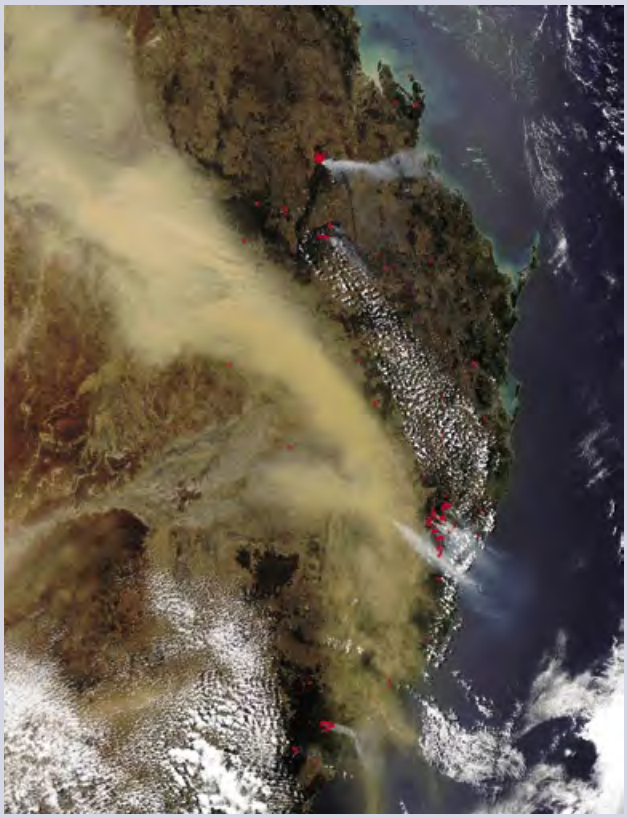
Case study: Visible effects of a dust storm

On Wednesday 23 October 2002 a severe dust storm affected visibility across the eastern states of Australia. The dust storm originated in South Australia and moved across western Queensland and New South Wales, reaching Australia's east coast at dusk. The Bureau of Meteorology estimated that the dust storm covered an area 1500 km long and 400 km wide and rose 2.5 km into the atmosphere. The spring winds collected millions of tonnes of topsoil as they traversed the drought-ravaged landscapes of inland Australia.

Visibility in some areas of western Queensland was as low as 100 metres.



Visibility in Longreach was reported at 1500 m during the dust storm in October 2002. (Photo: BoM)



A satellite image of the 23 October 2002 dust storm crossing eastern Australia. The red dots indicate scattered fires. Source: NASA 2002

Bushfires also contributed to the low visibility and high PM_{10} levels on the Darling Downs and in Mackay during the dust storm.

Queensland Health advised that asthmatics and other persons with respiratory conditions should stay indoors and close their windows to reduce their exposure to the fine particles suspended in the dust storm.

The storm persisted for two to three days in many areas along the Queensland coast before moving out to sea.

Figure 3.22 shows the exceedences of the state (Air EPP) and national (Air NEPM) standards for PM_{10} that occurred in the week surrounding the dust storm. The dust storm caused elevated levels at all of the EPA's air quality monitoring stations for a number of days while it moved across Queensland and out to sea. As the dust began to disperse and settle, particle levels returned to normal.

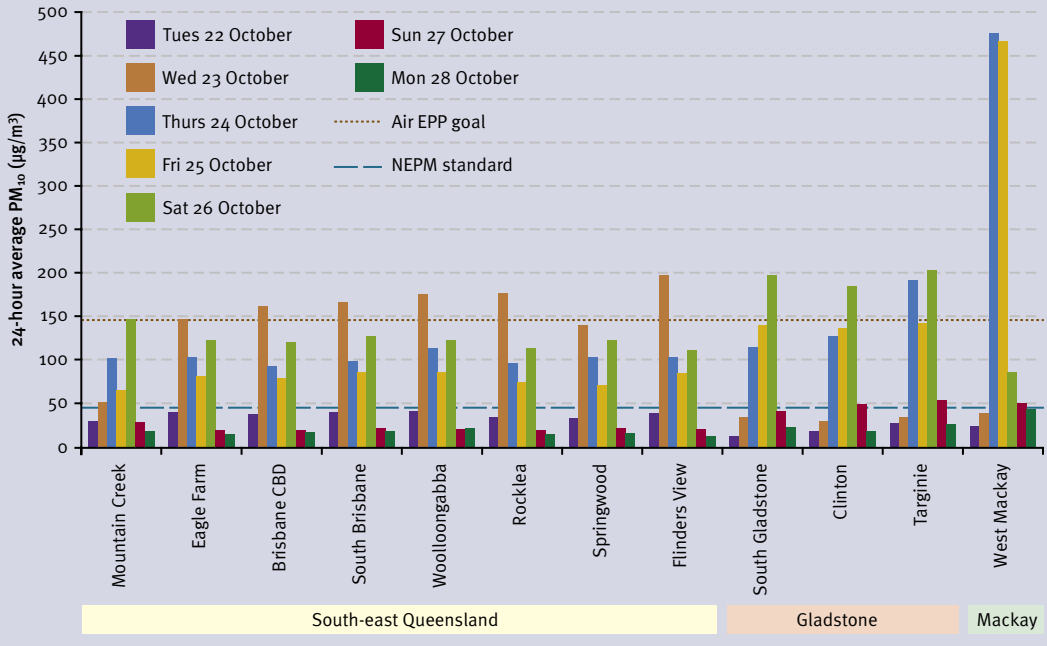


Figure 3.22 *PM_{10} levels measured in Queensland in the days before and after the dust storm of 23 October 2002*

Air toxics

Summary

As concentrations of pollutants such as sulfur dioxide and lead have decreased and become less of a concern in most areas of Queensland, attention has turned to other emerging air quality issues. Prolonged exposure to air toxics, even at low concentrations, may have serious health and environmental effects. Understanding of and information on ambient levels and the short- and long-term impacts of these pollutants are limited.

Air toxics come from a variety of sources including paints, solvents, lawn mowers, motor vehicle fuels, coal-fired power stations, pesticides, wood heaters, incinerators, bushfires, cigarette smoking, furnishings and building products. In recent years, the National Pollutant Inventory, in which industries and government estimate and report emissions of pollutants, has provided information on the amounts of air toxics emitted in Australia. Studies are currently under way to determine the levels of certain air toxics in Australia and will be used to develop regulations that manage air toxics and protect our health and environment.

Description

Air toxics, also referred to as 'hazardous air pollutants' (HAPs), are aerosol or particulate contaminants present in the ambient air in trace amounts that have characteristics, such as toxicity and persistence, that may make them a hazard to human health, plant production and animal life (OECD 1995).

Pollutants described as air toxics include:

- benzene;
- formaldehyde;
- 1,3-butadiene;
- dioxins;
- chlorinated hydrocarbons;
- polycyclic aromatic hydrocarbons (PAHs);
- toluene; and
- xylenes.

Air toxics may affect the central nervous system, the development of children and foetal development. Short-term exposure to high levels of air toxics may exacerbate asthma and cause breathing difficulties. Air toxics may also cause cancer. Aquatic life and vegetation can also be damaged by their effects.

Pressures

Air toxics are emitted from a wide range of sources. Motor vehicles are the main source of benzene and toluene in south-east Queensland (table 3.10). Area-based emissions are those from commercial and residential activities or substances, such as dry cleaning, lawn mowing, solvents, wood heaters, and cigarette smoke. Area-based sources contribute the highest proportion of xylenes (44%) and, along with industry (particularly metal industries), are a significant contributor of air toxics such as toluene and benzene.

Table 3.10 Benzene, toluene and xylenes emissions from anthropogenic sources in south-east Queensland, 2000

Source	Benzene		Toluene		*o*-, *m*-, *p*-xylene	
	t/year	%	t/year	%	t/year	%
Motor vehicles	2277	76	3583	40	1531	35
Industry	111	4	2897	32	592	13
Other mobile*	190	6	357	4	351	8
Area-based	428	14	2145	24	1918	44
Total	**3006**	**100**	**8982**	**100**	**4392**	**100**

*Includes air, rail and marine transport.

Source: EPA 2003a

Before 2003 there were no national goals or standards for ambient levels of air toxics. In 2003 the NEPC released the draft National Environment Protection (Air Toxics) Measure for public consultation. It includes goals for a variety of air toxics. Investigation levels for air toxics are generally based on annual averages, as they are derived from levels that cause health effects after lifetime exposures.

In the past, air quality monitoring networks have focused on the assessment of the ambient levels of criteria pollutants in the air. Criteria pollutants are the air pollutants traditionally regarded as important in urban air: sulfur dioxide, carbon monoxide, nitrogen dioxide, ozone, particulate matter and lead (particulate and vapours). However, community concern about air toxics has led to the need for more information about the location, sources and quantities of air toxics released and their impact on our health. Long-term data are needed to assess the impacts of air toxics. Limited monitoring of air toxics has occurred in Australia for selected pollutants. Further monitoring to determine ambient levels of air toxics and studies to assess exposure limits are currently occurring so that management strategies for air toxics can be introduced in Australia.

Several issues are associated with determining ambient air toxic levels:

- relatively few methods are available to monitor air toxics, and these are costly in terms of labour and equipment;
- equipment may not be able to detect concentrations where levels are very low; and
- the distribution of air toxics within an airshed is far from uniform, higher levels being found near major sources or clusters of sources (NEPC 2001a).

Condition and trends

The EPA monitors benzene, toluene and xylene concentrations at Springwood and the Brisbane CBD in south-east Queensland, and monitored concentrations at Wynnum until 2002. The Springwood station is located close to the South East Freeway; the Brisbane CBD station measures air toxics within the city; and the Wynnum station is in the vicinity of petroleum refineries and the port of Brisbane. Benzene and toluene are also monitored at Targinie in Gladstone to assess the impact of industry emissions.

The draft Air Toxics NEPM standard for benzene is an annual average of 3 parts per billion (ppb). The EPA is using this level to evaluate ambient benzene concentrations. Annual levels of benzene in south-east Queensland and Gladstone are around 1 ppb, well within the proposed level (figure 3.23).

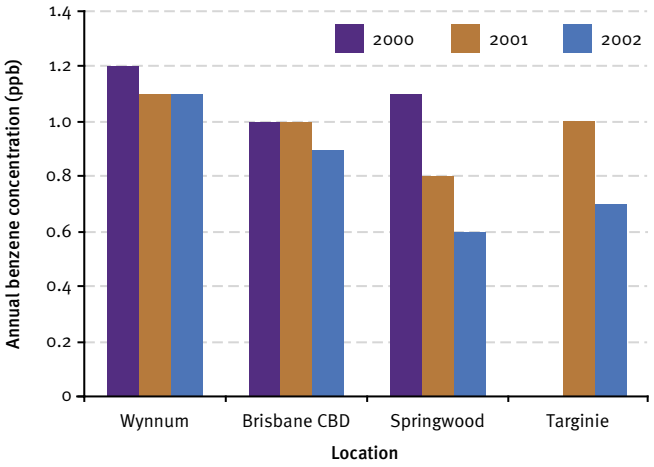


Figure 3.23 *Annual benzene concentrations in south-east Queensland and Gladstone, 2000–02*
Source: EPA

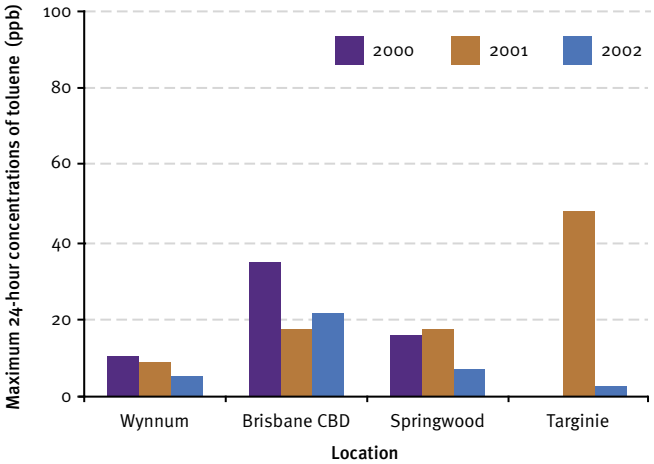


Figure 3.24 *Maximum 24-hour concentrations of toluene in south-east Queensland and Gladstone, 2000–02*
Source: EPA

Queensland's Air EPP sets a maximum 24-hour average of 2000 ppb for toluene levels; this is consistent with the draft Air Toxics NEPM proposed investigation level. Figure 3.24 shows that toluene levels are well below this standard. Maximum toluene levels in south-east Queensland are around 20 ppb. In 2001 at Targinie (Gladstone), the maximum toluene concentration of 48 ppb was attributed to burning of bushland adjacent to the monitoring site where eucalypt species, which contain considerable amounts of natural oils, were burning (EPA 2003b).

Figure 3.25 shows the maximum daily concentrations of *p*-xylene measured at south-east Queensland monitoring stations in 2000–02. The draft Air Toxics NEPM includes a proposed investigation level for total xylenes that is a maximum 24-hour concentration equivalent to 200 ppb. Studies have determined that *p*-xylene (one of the three isomers of xylene) makes up approximately 20% of the total xylene fraction in urban air (EPA 2003b). The highest recorded *p*-xylene concentration in south-east Queensland was 3 ppb, measured at Wynnum. This is much lower than the draft Air Toxics NEPM investigation level for xylenes.

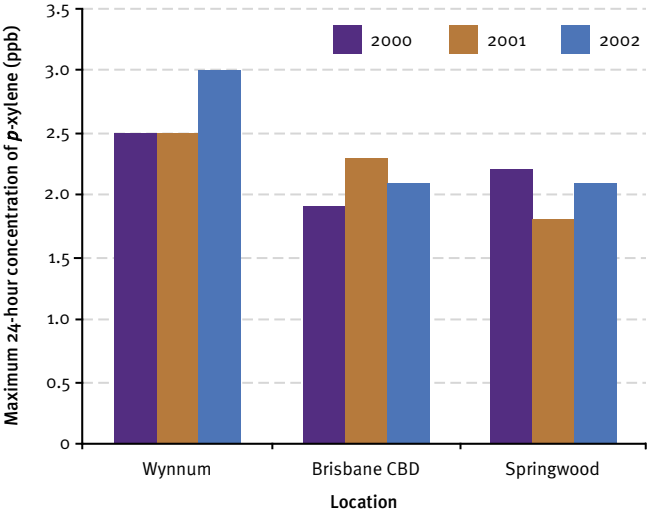


Figure 3.25 *Maximum 24-hour concentrations of* p-*xylene in south-east Queensland, 2000–02*
Source: EPA

Current measurements of concentrations of air toxics indicate that levels are well below draft national and international standards and goals. Further information is needed to understand the impact of these levels on our health and environment, however.

Summary of condition and trend indicators

Air toxics

Indicator	SEQ	Gladstone
Exceedences of draft Air Toxics NEPM investigation level for benzene		
Exceedences of draft Air Toxics NEPM investigation level for toluene		
Exceedences of draft Air Toxics NEPM investigation level for xylenes		

Key to condition:

Good = the proportion of time that ambient levels were below 50% of the standard in 1999–2002

Moderate = the proportion of time that ambient levels were between 50% and 100% of the standard in 1999–2002

Poor = the proportion of time that ambient levels were above the standard in 1999–2002

Responses

Concerns about the health effects, sources and acceptable emission levels of air toxics have resulted in efforts to learn more about these substances.

The Living Cities—Air Toxics Program began in 1999. Its *State of Knowledge Report: Air Toxics and Indoor Air Quality in Australia*, completed in 2002, provides a reference point to help governments, industry and the public work together to develop appropriate management strategies (EA 2001). The report:

- contains a definition of air toxics;
- identifies broad categories of air toxics and their sources;
- identifies the list of priority pollutants developed under the program;
- considers existing Australian and international approaches to managing air toxics; and
- provides Australian case studies dealing with air toxics in ambient air.

One of the outcomes of the program was the recommendation for the development of an NEPM for the management of air toxics. Any NEPM developed would require support from each state and territory and consultation with industry, community and other stakeholder groups affected by the legislation. On 29 June 2001, the NEPC resolved to develop an NEPM for Ambient Air Toxics (Air Toxics NEPM). The Air Toxics NEPM will focus on five pollutants:

- benzene,
- formaldehyde,
- PAHs,
- toluene, and
- xylenes.

The NEPC released an issues paper in September 2001 and a discussion paper in March 2002. In May 2003 it released a draft Air Toxics NEPM and associated impact statement for public consultation (NEPC 2003).

Reporting of some air toxics is currently required under the National Environment Protection (National Pollutant Inventory) Measure (NPI NEPM). In June 2000 the NPI NEPM was varied to increase, from July 2001, the number of substances required to be reported to the National Pollutant Inventory (NEPC 2000). This information about the emission sources and quantities of air toxics released into the atmosphere increases our knowledge about air toxics in Australia.

To provide further information on the current ambient levels of some air toxics, Queensland and other states have undertaken monitoring programs. A selection of air toxics, including benzene, toluene and xylene isomers, are now being measured by the EPA in Gladstone and south-east Queensland.



New fuel quality standards will reduce the amounts of toxic air pollutants, such as benzene, released from motor vehicle exhausts. (Photo: GCCC)

The Fuel Quality Standards Act was passed in 2000 by the Commonwealth Government. It provides a framework that will allow the Commonwealth Government to set mandatory quality standards for fuel supplied in Australia. The fuel quality standards will reduce the levels of some air toxics, such as benzene, in ambient air by specifying a maximum allowable level in fuels (EA 2003b). Emissions of air toxics from new motor vehicles are controlled through Australian design rules that set emission standards for a range of pollutants including hydrocarbons.

Queensland's *Environmental Protection (Air) Policy 1997* provides air quality guidelines for twelve air toxics, including toluene. Emissions from environmentally relevant activities that are licensed through the *Environmental Protection Act 1994* can be controlled by setting conditions such as emission limits of pollutants.

Other pollutants

Summary

Air quality across Queensland is generally good and better than state and national standards for carbon monoxide, nitrogen dioxide, lead and sulfur dioxide. Intermittent elevated sulfur dioxide levels in Mount Isa are influenced by the presence of a major industry in the city. Pollutant emissions come from natural sources (vegetation burning and dust) and anthropogenic sources (such as transport and industry). Regulation of air pollutant releases from their source (such as car exhaust emissions) is a key factor in reducing pollutant emissions and concentrations. The reduction in lead concentrations in ambient air as a result of the reduction and removal of lead in petrol in the past two decades is an example of the way air pollutant levels can be managed and controlled to protect the environment and health.

Description

High concentrations of carbon monoxide (CO), nitrogen dioxide (NO_2) and sulfur dioxide (SO_2) can affect our health and environment. Descriptions of some air pollutants and their effects are included in the Glossary. Sustainable management and protection of the air environment are important to ensure that air quality does not deteriorate below safe levels.

Motor vehicles are the largest contributor to air pollution in south-east Queensland, particularly for oxides of nitrogen (NO_X) and for CO (EPA 2003a). NO_X is a mixture of nitric oxide (NO) and nitrogen dioxide (NO_2). In urban areas we have become increasingly reliant on private motor vehicles for transport rather than alternatives such as public and non-motorised transport. Our reliance on motor vehicles continues with our increasing population growth and the geographic expansion of regional centres, increasing the distances we travel for employment and other activities.

Large-scale industries such as mining, petroleum refining and electricity generation are major contributors to Queensland's economy. The use of fossil fuels as an energy source in many industrial activities produces significant emissions of SO_2 and NO_X.

Emissions also arise from natural sources, including windblown dust, pollens and biological activities. These emissions include NO_X and VOCs, which influence the development of photochemical smog (see 'Photochemical smog', page 3.17). Vegetation burning is another infrequent but significant source of pollution, especially particles, and includes bushfires, hazard-reduction burning and agricultural burning (see 'Particle pollution and reduced visibility', page 3.21).

For most of the year, pollutant levels measured at air quality monitoring sites in Queensland conform to national standards. Management of the key sources of air pollutants, reliable air quality information and action by the community are needed to ensure that air quality remains within acceptable levels.

Pressures

Air quality is dependent on many factors, including the amount of pollution emitted, its release location and weather conditions. For example, most NO_X is generated from motor vehicles and industry and can react to form photochemical smog under conducive weather conditions (see 'Photochemical smog'). Depending on weather conditions, this pollution may stagnate near its source or travel on winds to other areas where little pollution has been generated by local sources but where pollutant concentrations may be elevated because of the release and movement of pollution from other areas. Weather conditions can be forecast and modelled for scenarios but cannot be controlled to limit pollution levels. Controlling the amount of pollution released at a location is the key to limiting air pollution.

Table 3.11 Air emissions in south-east Queensland from anthropogenic sources in 2000

Source	NO_X		CO		SO_2	
	t/year	%	t/year	%	t/year	%
Motor vehicles	60 579	70.9	417 317	88.3	1 871	7.6
Other mobile	9 104	10.6	22 183	4.7	4 147	17.0
Industry	15 450	18.1	19 339	4.1	18 328	75.0
Area-based	365	0.4	13 492	2.9	100	0.4
Total	**85 498**	**100.0**	**472 331**	**100.0**	**24 446**	**100.0**

Source: EPA 2003a

Table 3.11 shows that motor vehicles are the highest source of NO_X emissions in south-east Queensland (almost 71%), followed by industry (just over 18%).

South-east Queensland is home to 65% of the state's population. More than 80% of Queensland's population growth between 1996 and 2001 occurred there. This population growth is occurring mainly in low-density suburbs, expanding the urban areas of the region. This expansion is expected to cause an increase in the use of motor vehicles and distance travelled. Motor vehicle travel in south-east Queensland was estimated as 21 362 million kilometres in 2000. This is expected to grow by 30–60% by 2011 (EPA 2003a), depending on:

- how fast the population grows, and where;
- where employment centres are developed in relation to where people live;
- whether private vehicle use increases or decreases;
- whether private vehicle trips lengthen; and
- whether public transport use increases or decreases.

For further discussion on population growth and distribution, see Chapter 8, 'Human settlements'.



Traffic and pedestrian bridges—the Captain Cook Bridge (foreground) takes commuter vehicle traffic, while the Goodwill Bridge (background) is used by pedestrians and cyclists to cross the Brisbane River. (Photo: L. Knight, EPA)

In urban south-east Queensland, motor vehicles account for the majority of CO emissions (88.3%) (EPA 2003a). Industrial fuel burning processes, domestic wood heaters and bushfires are other sources of carbon monoxide.

Sulfur dioxide emissions are produced from the smelting of sulfide ores and the combustion of fuels containing sulfur. Motor vehicle fuels in Australia have a low sulfur content. In south-east Queensland motor vehicles contribute only around 8% of SO_2 emissions. By comparison, industry contributes 75% of SO_2 emissions (figure 3.26). More than half of the industrial emissions in the region are from power generation (9620 tonnes). The petroleum refining industry, another major industrial contributor in south-east Queensland, produces another quarter (5156 tonnes). Power generation alone emits more than five times as much SO_2 as motor vehicle exhaust emissions. The contribution of industry to SO_2 emissions is higher in other regions with lower population and more extensive industry, including Gladstone, Townsville and Mount Isa. The greatest influence from industrial emissions of SO_2 occurs in Mount Isa as a result of smelting operations (see 'Sulfur dioxide in Mount Isa', pages 3.38–3.39).

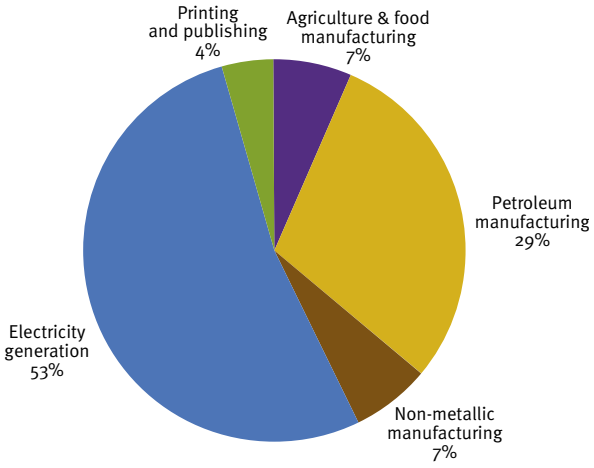


Figure 3.26 *Sources of industrial emissions of sulfur dioxide in south-east Queensland, 2000*

As Queensland's population and motor vehicle use continue to grow, emissions of NO_x and CO will continue to increase, particularly in the south-east, unless ongoing emission control technologies are implemented and planned improvements in the transport system occur. The management of industrial emissions of NO_x and SO_2 is also an important consideration in regions where major industries operate and future expansions are proposed.

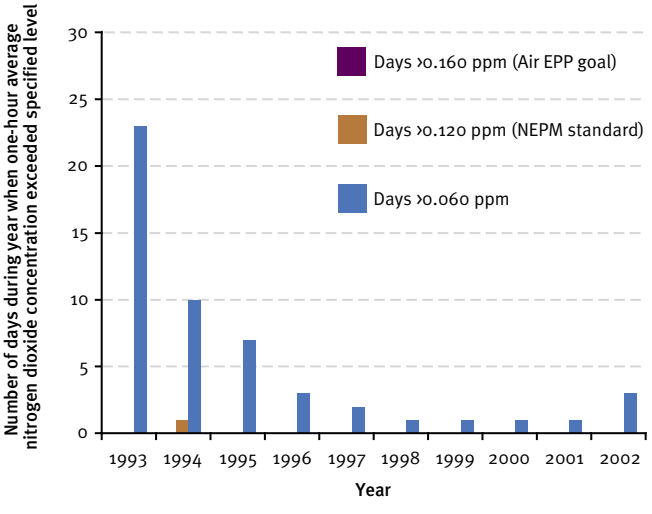
Condition and trends

Air quality across Queensland is reasonably good and better than state and national standards for CO, NO_2 and SO_2. Intermittent elevated SO_2 levels in Mount Isa are influenced by the location of a major industry in the city. The desired environmental outcome of the air quality standards set in the National Environment Protection (Ambient Air Quality) Measure 1998 (Air NEPM) is the adequate protection of human health and wellbeing. Table 3.8 (page 3.23) shows the pollutants measured at EPA air quality monitoring sites in Queensland. Table 3.9 (page 3.24) provides the Air NEPM standards.

Nitrogen dioxide

Measurements in south-east Queensland and Gladstone show that NO_2 levels are consistently better than the Air NEPM standard. The number of stations monitoring NO_2 increased for both regions in the 1990s.

There have been no exceedences of the Air NEPM standard in south-east Queensland since 1994 (figure 3.27). The number of days on which NO_2 levels reached half the standard (0.06 ppm) has continued to decline since 1993; this occurred on only one day each year in the period 1998–2001. A small rise in NO_2 concentrations has been measured since 2000, although the general trend since 1993 has been downward. Monitoring results at sites in the outer south-east Queensland region are generally lower than those measured at metropolitan Brisbane sites, where traffic emissions of NO_2 are higher (figure 3.28). The south-east Queensland NO_2 monitoring network was expanded in 2002 to include sites at Maroochydore and South Brisbane. The South Brisbane station is located adjacent to the South East Freeway; its location near the traffic corridor is responsible for the higher number of 0.06 ppm NO_2 concentrations measured in 2002.



	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
Maximum (ppm)	0.100	0.122	0.079	0.079	0.074	0.066	0.099	0.061	0.078	0.065
Number of sites	4	6	9	9	9	10	12	11	11	13
Data availability	75%	61%	71%	77%	91%	89%	76%	91%	94%	80%

Figure 3.27 *Regional trend in one-hour average nitrogen dioxide concentrations in south-east Queensland, 1993–2002*

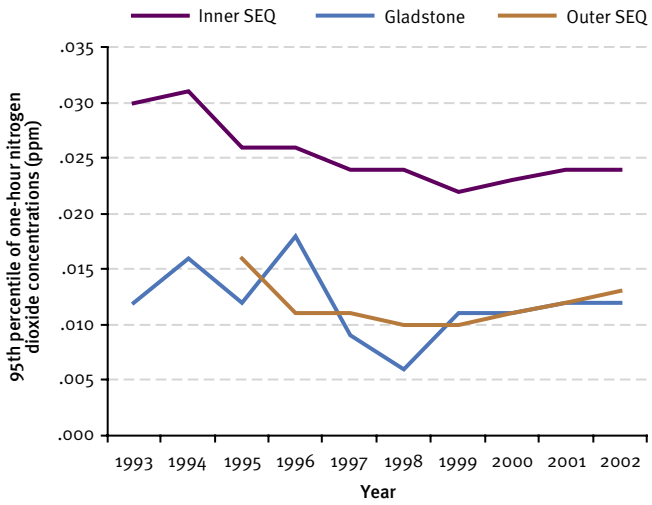


Figure 3.28 *Trend in 95th percentiles for one-hour nitrogen dioxide concentrations, 1993–2002*

In the Gladstone region, NO_2 levels have been relatively low, rarely reaching half of the Air NEPM standard. Measurements indicate a small increase in NO_2 concentrations from 2000 to 2002. Increased production by several industries in the region (with a corresponding increase in total emissions) is likely to be responsible for this slight rise.

Carbon monoxide

Carbon monoxide (CO) is measured only in south-east Queensland, at sites located in Brisbane's inner-city area close to major traffic corridors. CO emissions in the region increased by 88 596 tonnes between 1993 and 2000 as a result of increases in population and vehicle travel, even though motor vehicle technologies have improved (EPA 2003a). CO concentrations tend to be higher during winter, due to still conditions that limit dispersion of pollutants from the vicinity of the emission.

Elevated ambient CO levels usually occur only in urban centres and are highest in congested inner-city streets. There have been no exceedences of the Air NEPM standard of 9 ppm in south-east Queensland in the past ten years. Generally, CO levels reach half the Air NEPM standard on only a few occasions each year.

Figure 3.29 shows the yearly variation in CO levels at the Woolloongabba and Brisbane CBD monitoring sites in recent years. The CO monitoring stations reflect the local air quality at these sites, which are near traffic corridors. The Woolloongabba station, located only 4 m from a major roadway, reflects the higher concentrations measured closer to the traffic. The Brisbane CBD station is further away from traffic.

Monitoring for CO began at South Brisbane near the South East Freeway in late 2002, and at Toowoomba in 2003. Monitoring data from the EPA's network of monitoring stations are updated throughout the day on the EPA website, ‹http://www.epa.qld.gov.au/projects/air/›.

While levels at the Brisbane CBD monitoring location have fallen since 1999, CO concentrations at Woolloongabba (and, by association, adjacent to other major roads) have remained relatively constant over the period of monitoring at this site.

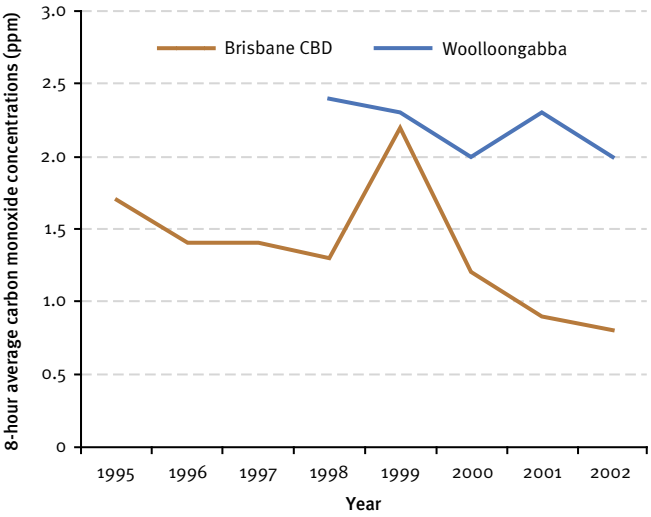


Figure 3.29 *Trend in 95th percentiles for eight-hour carbon monoxide concentrations, 1995–2002*



The South Brisbane air quality monitoring station located alongside the South East Freeway is operated for the Department of Main Roads by the EPA. (Photo: EPA)

Sulfur dioxide

Sulfur dioxide (SO_2) is measured at Mount Isa, Townsville and Gladstone and in south-east Queensland (figure 3.30). Heavy industries, burning fossil fuels, are the main contributor to SO_2 emissions. Concentrations of SO_2 measured in Townsville, south-east Queensland and Gladstone remain within the Air NEPM standards (table 3.12). In Mount Isa, SO_2 concentrations exceed those standards on a number of occasions each year due to smelting operations located in the city.

In south-east Queensland, levels rarely reach a quarter of the Air NEPM one-hour SO_2 standard of 0.20 ppm, as there are only a limited number of significant SO_2 emission sources in the region. Motor vehicle fuels used in south-east Queensland have a low sulfur content, limiting SO_2 emissions from the region's motor vehicle fleet. Concentrations of SO_2 have been decreasing over most of the region in recent years. An increase in the generating capacity of the Swanbank coal-fired power station in the late 1990s resulted in increased SO_2 concentrations being measured at Flinders View, the monitoring site closest to the power station (figure 3.30).

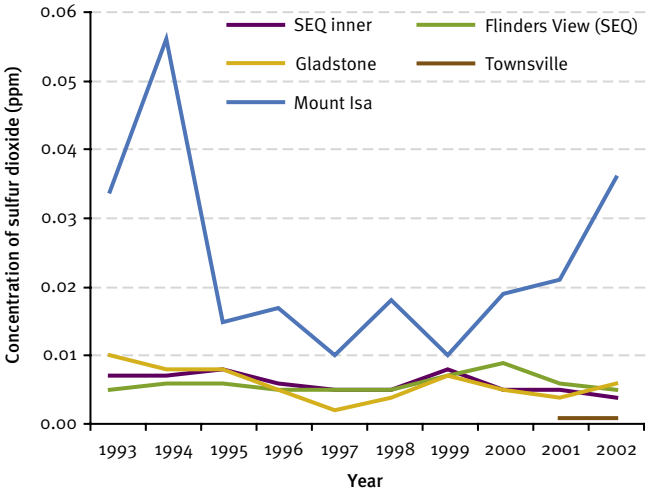


Figure 3.30 *Trend in 95th percentiles for one-hour sulfur dioxide concentrations, 1993–2002*

In Gladstone, SO_2 levels rarely exceed half the one-hour Air NEPM standard and there have been no exceedences of the standard in the past decade. Several major industries in the Gladstone region converted from coal to natural gas as a fuel source in the mid-1980s, reducing the total emissions and concentrations of SO_2. Releases from elevated industry stacks allow for the dispersion of pollutants and reduce their ground-level concentrations.

Mount Isa

Sulfur dioxide concentrations in Mount Isa have been below the annual Air NEPM standard since the mid-1990s. However, SO_2 emissions from lead and copper smelting operations in Mount Isa cause exceedences of the Air NEPM one-hour and 24-hour SO_2 standards. The EPA's Menzies station in Mount Isa recorded 50 exceedences (on 31 days) of the one-hour standard in 2000, 53 exceedences (on 41 days) in 2001, and 73 exceedences (on 49 days) in 2002. In 2002, the one-day standard was exceeded for the first time since 1994. The smelter operations are regulated to meet air quality limits set in the *Mount Isa Mines Limited Agreement Act 1985*, which correspond to the United States Environmental Protection Agency (USEPA) primary and secondary standards for ambient SO_2 levels.

Ambient SO_2 levels in Mount Isa gradually decreased in the past ten years as the management of air quality in the populated areas of Mount Isa improved. In 2000, a sulfuric acid plant began using the majority of the SO_2 emissions previously discharged from the smelter. This allowed the smelter to run at a higher rate of production more often without approaching its set limits and resulted in a rise in the trend of SO_2 concentrations measured in Mount Isa since 2000 (figure 3.30).



Gladstone is a major industrial centre in Queensland. (Photo: EPA)

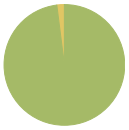
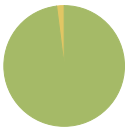
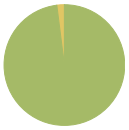
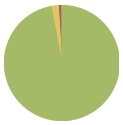
Table 3.12 Number of days sulfur dioxide one-hour measurements exceeded certain levels in Queensland regions, 1999–2002

Region	1999			2000			2001			2002		
	0.05 ppm	0.10 ppm	0.20 ppm	0.05 ppm	0.10 ppm	0.20 ppm	0.05 ppm	0.10 ppm	0.20 ppm	0.05 ppm	0.10 ppm	0.20 ppm
South-east Queensland	2	0	0	2	0	0	3	0	0	1	0	0
Gladstone	11	0	0	5	0	0	11	1	0	9	1	0
Townsville							0	0	0	0	0	0
Mount Isa	72	52	17	81	61	31	88	61	41	102	83	49

0.20 ppm = Air NEPM one-hour standard
0.10 ppm = ½ Air NEPM one-hour standard
0.05 ppm = ¼ Air NEPM one-hour standard

Summary of condition and trend indicators

Other pollutants

Indicator	SEQ	Gladstone	Rockhampton	Mackay	Townsville	Mount Isa
Exceedences of Air NEPM standard for NO_2						
Exceedences of Air NEPM standard for CO						
Exceedences of Air NEPM standard for SO_2						

Key to condition:

Good = the proportion of time that ambient levels were below 50% of the standard in 1999–2002

Moderate = the proportion of time that ambient levels were between 50% and 100% of the standard in 1999–2002

Poor = the proportion of time that ambient levels were above the standard in 1999–2002

Responses

Most air pollution in populated areas arises from human activities in the transport, industry and employment sectors. Private motor vehicles are a major contributor to air pollution in urban regions, particularly by NO_2 and CO. Current measures and actions being undertaken to reduce air pollution from transport are described below:

- The joint Land Transport Environment Committee and National Environment Protection Council (NEPC) proposed the introduction of Australian design rules that will result in tighter pollutant emission limits to offset the predicted increase in vehicle kilometres travelled.
- The introduction of more stringent fuel standards for motor vehicles continued in recent years. In 2000 Queensland introduced regulations that limit the sulfur content of diesel fuel to 500 ppm. These regulations also required the phasing-out of leaded petrol in Queensland by March 2001, in advance of most other states in Australia. Further information on leaded petrol and lead concentrations in Queensland is included in the case study on page 3.40.



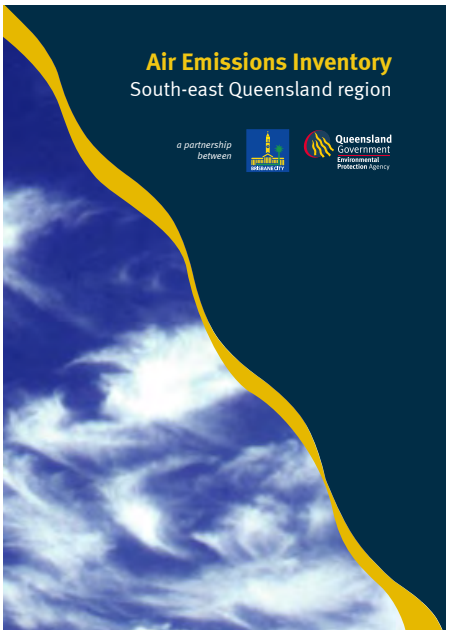
Physical activity such as walking and cycling has health benefits and leads to improved air quality. (Photo: L. Knight, EPA)

- The Queensland Department of Main Roads has funded the operation of an air quality monitoring station at South Brisbane, adjacent to the South East Freeway, to measure NO_2, CO and particle levels close to this major road corridor.
- The South East Queensland Integrated Regional Transport Plan (SEQ IRTP) is part of the SEQ 2021 regional planning process for south-east Queensland. It outlines actions and strategies that can benefit air quality through transport planning, including supporting and increasing public transport use (for example, integrated ticketing on public transport). New projects such as the AirTrain to and from Brisbane Airport and the South East Busway are providing public transport options that will enable the community to reduce motor vehicle use.

Actions and strategies to reduce pollutant emissions and raise community awareness of pollutant sources and what can be done to improve air quality are described below:

- Queensland, the Commonwealth and other states and territories are implementing Air NEPM monitoring plans to assess regional air quality across Australia against the Air NEPM standards and the attainment of the NEPM's goal, to achieve compliance with these standards. The EPA completed Queensland's Air NEPM monitoring plan in 2001. Each year Queensland provides a monitoring report to the NEPC on the state's monitoring results and progress towards this goal.
- The South East Queensland Regional Air Quality Strategy (SEQRAQS) was finalised in 1999 as part of the SEQ 2001 regional planning process. The aim of SEQRAQS is to improve air quality in south-east Queensland in order to protect the health and wellbeing of present and future residents, and to preserve the region's ecological integrity and amenity. It describes strategies and actions that can be taken to maintain and improve the region's air quality under a number of categories, including transport, industry, monitoring, research and raising community awareness. The SEQRAQS Implementation Group, consisting of government, industry and community representatives, is currently updating the strategy.

- In 2003, the EPA and Brisbane City Council released the *Air Emissions Inventory* for south-east Queensland as part of the joint South-east Queensland Airshed Study. The *Air Emissions Inventory* will be used in conjunction with air quality modelling and monitoring programs to aid in decision making to ensure that air quality is maintained as the region develops.



The Air Emissions Inventory *for south-east Queensland was a joint project of the EPA and Brisbane City Council.*

- The EPA is implementing the National AirWatch program in cooperation with Environment Australia and other state environment agencies. AirWatch is a program promoting students' awareness of the environment, focusing on air pollution and what students can do to change their behaviour to reduce air pollution.
- The National Pollutant Inventory (NPI) ‹www.npi.gov.au› is a database of air, land and water pollution across Australia. It includes annual emissions from industrial and commercial facilities required to report under the National Environment Protection (National Pollutant Inventory) Measure, along with estimated emissions for general activities including use of motor vehicles and lawn mowers. The NPI is designed to give communities access to information about pollution in their local area. NPI reporting began in 1999 and the number of reportable substances has been expanded in recent years. Currently 3000 facilities, including 746 in Queensland, report to the NPI.
- The Queensland Government commissioned the Mount Isa Mines Limited Panel Assessment Study in 1998 to assess the impacts of SO_2 emissions on the environment, community and economy of Mount Isa. The study was completed in 2001 and included a number of recommendations. The case study below provides an overview of the findings and recommendations of the report.

Case study: Sulfur dioxide in Mount Isa

Mount Isa is located in north-west Queensland. Mount Isa Mines Limited operates a copper and lead smelter on the outskirts of Mount Isa. The smelter operations emit a considerable amount of sulfur dioxide (SO_2) to the atmosphere. Residents of the town can be exposed to elevated SO_2 levels when weather conditions cause emissions from the smelter's stacks to blow over the township. SO_2 can affect human health by causing respiratory irritations and increasing susceptibility to respiratory tract infections.

The EPA began monitoring SO_2 at its Menzies station in Mount Isa in 1979. SO_2 levels in Mount Isa are compared to two sets of air quality standards, the Air NEPM standards (used throughout Australia) and United States Environmental Protection Agency (USEPA) secondary standard (table 3.13). Under the *Mount Isa Mines Limited Agreement Act 1985*, the company's smelter operations must be managed to maintain ambient SO_2 concentrations in Mount Isa below levels equivalent to the USEPA secondary standard. The one-hour and 24-hour Air NEPM standards are intermittently exceeded at the Menzies station. The USEPA standard by which the smelter operations are assessed has not been exceeded at the Menzies station in recent years; however, the assessment against these standards for compliance with licence conditions is based on monitoring undertaken by the company at its own suite of monitoring stations, not the EPA's ambient air monitoring station at Menzies.

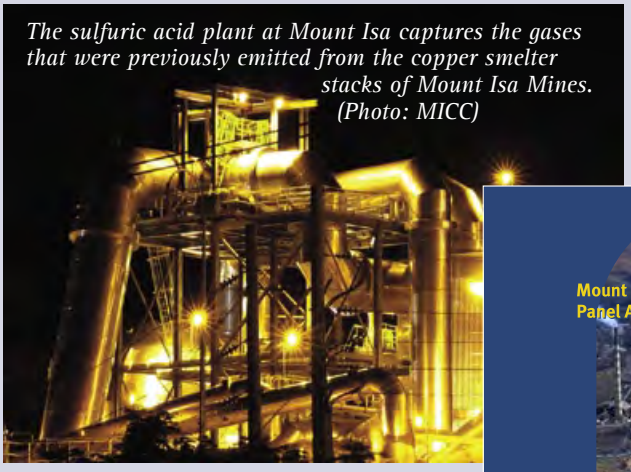
Table 3.13 USEPA and Air NEPM standards for SO_2

Standard	Averaging period	Maximum concentration (ppm)	Maximum allowable exceedences
USEPA secondary standard	3 hours	0.50	1 day a year
Air NEPM standard for SO_2	1 hour 1 day 1 year	0.20 0.08 0.02	1 day a year 1 day a year None

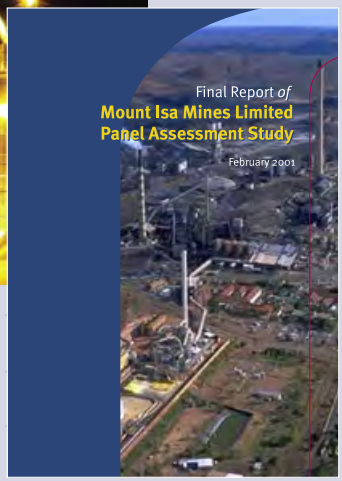
The company's Air Quality Control Centre monitors ambient SO_2 levels and meteorological conditions and adjusts the smelter operations, either through shutdowns or by running at partial capacity, to ensure that SO_2 concentrations at ground-level monitoring sites remain within the company's licence limits.

Figure 3.31 shows the SO_2 stack emissions at Mount Isa in the years 1998–2002. Lower SO_2 emissions in 2001 and 2002 reflect the capture of previously emitted copper smelter stack gases by the WMC Fertilizers sulfuric acid plant, which began operating in late 2000. Production rates increased in 2002, but the total SO_2 emissions decreased by 10% (MIM 2003) as more emissions were treated through the sulfuric acid plant. Emissions in 2002 were less than half of the emissions of SO_2 emitted in 2000, when the sulfuric acid plant began operation towards the end of the year and captured only 7% of the SO_2 smelter emissions. The higher rate of production allows the plant to operate closer to its emission limits for longer, and resulted in higher annual average SO_2 concentrations in 2001 and 2002.

Case study: Sulfur dioxide in Mount Isa *(continued)*



The sulfuric acid plant at Mount Isa captures the gases that were previously emitted from the copper smelter stacks of Mount Isa Mines. (Photo: MICC)



The Mount Isa Mines Limited Panel Assessment Study was completed in 2001. (Photo: EPA)

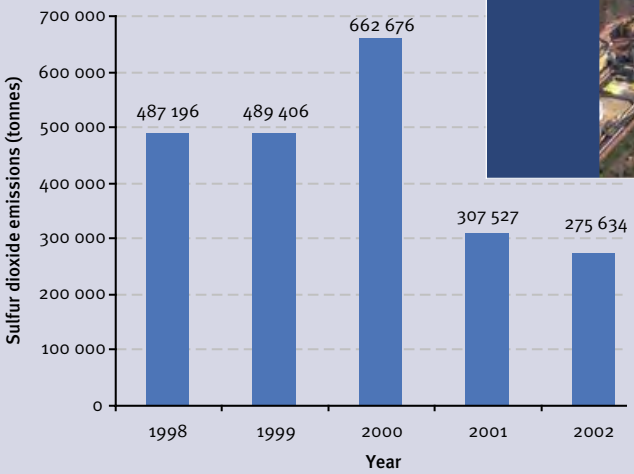


Figure 3.31 *Sulfur dioxide stack emissions at Mount Isa, 1998–2002*
Source: MIM 2003

In 1998 the Queensland Government commissioned the Mount Isa Mines Limited Panel Assessment Study to assess the impacts of SO_2 emissions on the environment, community and economy of Mount Isa (EPA 2001b). The reports from the study are available on the EPA's website ‹www.epa.qld.gov.au›. Key findings of the study were that:

- no SO_2 impact on flora or fauna was observable beyond 20 km downwind of the smelters;
- sulfur deposition from emissions causing acidification is limited to the top 10 cm of soil within 5 km downwind of the smelters, and limited to the top 2 cm of soil within 20 km downwind; and
- no evidence was found of adverse effects of SO_2 emissions on the health of the population in the hospital admission statistics at Mount Isa.

Key recommendations from the study were that:

- a monitor be appointed to report on progress of the implementation of the recommendations;
- monitoring of SO_2 be continued, using passive gas samplers over 12 months of acid plant operation to confirm reductions in downwind exposure to SO_2;
- a monitoring program be implemented to identify signs of ecological recovery resulting from the expected reduction of SO_2 emissions; and
- practicable measures to further improve the effectiveness of the air quality control system be investigated.

Figure 3.32 shows the exceedences of the Air NEPM standards for SO_2. A consequence of the capture of SO_2 from the smelter to produce sulfuric acid is fewer smelter shutdowns to control air quality in Mount Isa and increased production. This, in turn, increases the potential for more frequent episodes where SO_2 concentrations in Mount Isa are below the Mount Isa Mines Limited Agreement Act limits but above the Air NEPM standards, as has been observed since 2000.

Mount Isa Mines has implemented some of the recommendations of the study. The WMC Fertilizers sulfuric acid plant is expected to use more than 80% of the smelter gas in 2003. Once this target is achieved, other recommendations, such as flora and fauna surveys, are expected to be implemented to assess the changes in environmental impact that result from the reuse of the smelter gas.

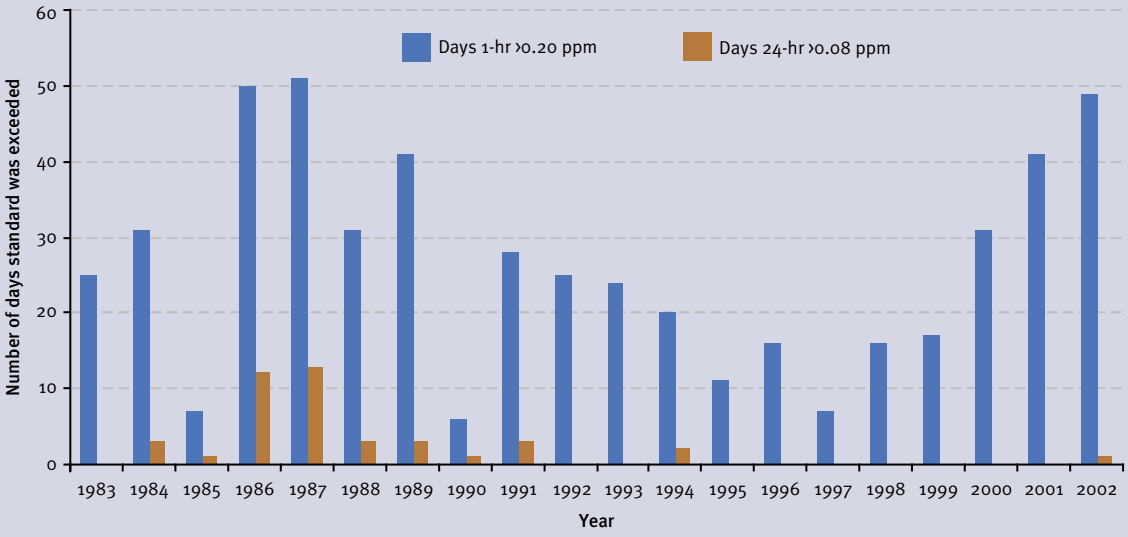


Figure 3.32 *Exceedences of the Air NEPM standards for sulfur dioxide in Mount Isa, 1983–2002*

Case study: Lead

Measured lead concentrations in Queensland's air have fallen dramatically in the past two decades. This is a result of the long-term reduction of lead in petrol and the eventual phasing-out of leaded petrol in Queensland. In the 1990s, motor vehicles accounted for more than 90% of all lead pollution emitted in urban areas. Smelting of mineral ores and manufacturing processes involving lead also contribute to lead pollution. Lead is emitted as particles, most of which settle close to the pollution source.

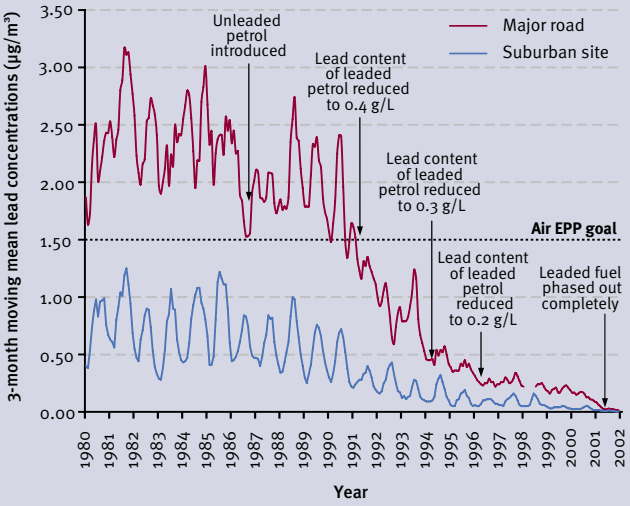


Figure 3.33 *Lead concentrations in south-east Queensland, 1980–2002*
Source: EPA

Lead affects the human central nervous system and may lead to impaired intellectual development in young children, and other conditions such as kidney disease in adults. Lead tends to accumulate in the body and is excreted very slowly. The Air EPP air quality standard for lead, 1.50 µg/m³, is averaged over three months to reflect the impact of long-term exposure to lead.

Monitoring in south-east Queensland, where motor vehicles are the major source of lead pollution, shows that there have been no exceedences of the lead standard for many years (figure 3.33). This is due to the introduction of unleaded petrol in 1986 and the continued reduction in the lead content of leaded petrol in the 1990s (from 0.84 g/L to 0.4 g/L in 1991, to 0.3 g/L in 1994, and 0.2 g/L in 1996), before the total phasing-out of leaded petrol in March 2001.

The EPA has monitored lead concentrations close to high-traffic road corridors since 1976. Monitoring ceased in 2002, when the average lead concentration at Woolloongabba in Brisbane was measured at 0.01 µg/m³.

Case study: Gladstone Airshed Study

In 1999 the Department of State Development funded the EPA to undertake the Gladstone Airshed Study. The study aimed to investigate the capacity of the Gladstone regional airshed to support the current and expected increases in industrial activity in the region while maintaining acceptable air quality as the region develops.

The combination of a deepwater harbour and proximity to large resources of raw materials has made the Gladstone region an ideal location for a number of Queensland's major industries. A power station, an alumina refinery, an aluminium smelter, a clinker plant, two sodium cyanide plants, a shale-oil extraction plant and major port operations are located within the Gladstone region. Emissions from many of these facilities are from tall stacks, reducing the ground-level concentrations and air quality impacts on the local population. In recent years several of these industries have expanded their operations, but the industrial growth has been offset by improvements in dust and emission controls at various facilities and the conversion from coal to 'cleaner' natural gas as a fuel source in the mid-1980s.

A review undertaken by the EPA identified the main air quality issues in the region and led to:

- the compilation of an air emissions inventory for the Gladstone region;
- the development of an air quality modelling system specific to the region; and
- the expansion of the existing air quality monitoring network for the duration of the study to provide data to validate the model.



The Port of Gladstone supports a number of major industries in the region. (Photo: EPA)

The emissions inventory and air monitoring data are necessary components for the operation of the Gladstone Airshed Modelling System (GAMS) developed for the Queensland Government by Katestone Environmental Pty Ltd. The modelling system was validated against the air quality monitoring that occurred. The model has two components, allowing it to simulate local and regional air quality impacts of new facilities or the expansion of existing industries.



Loading facilities at the Port of Gladstone (Photo: EPA)

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Transport and infrastructure (Photo: L. Knight, EPA)

4 Land

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Authors

Naidu Bodapati, Bruce Carey, Steve Crimp, Ram Dalal, Des McGarry, Greg McKeon, Phil Moody, Bernie Powell, Joe Scanlan and Grant Stone, Department of Natural Resources and Mines; Richard Silcock, Department of Primary Industries; John Bywater and Greg O'Brien, Environmental Protection Agency; Andrew Hammond and Grant McTainsh, Griffith University

Reviewers

Colin Creighton, former CEO of National Land and Water Resources Audit
Ross Hynes and David Gardiner, Department of Natural Resources and Mines

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Introduction

The quality of land resources in Queensland affects and is affected by human activities. Land is central to human existence and is an essential resource that:

- sustains ecological systems and maintains biodiversity;
- supports food, fibre and mineral production, which contributes to Queensland's economic wealth;
- provides living space and supports recreational activities;
- preserves geological, historical and evolutionary information and materials; and
- has spiritual, inspirational, scientific, cultural and educational value.

Where land use exceeds the capability of land resources, environmental damage and/or lowered productivity result. Some degrading processes are rapid (gully erosion and invading pests); some may occur episodically during extreme climatic events (wind and sheet erosion, and mass movement); others take decades to emerge (salinity).

The Queensland landscape has been greatly modified since European settlement, providing Queenslanders with primary produce that supports their way of life. The modification of the landscape has, however, also led to many forms of land degradation. The conversion of native vegetated landscapes for more intensive land uses without consideration of natural constraints is a major cause of land degradation. The cumulative environmental impacts of agriculture, grazing, mining, urbanisation and transport degrade the quality of land and vegetation resources. This degradation, in turn, can adversely affect agricultural production and biodiversity.



Mining is a significant contributor to Queensland's economy. (Photo: DNRM)

Changes in land practices and rehabilitation of degraded land can be achieved, but the restoration of degraded land can be difficult, long-term and expensive. In some cases, the degradation may be considered irreversible.

This chapter discusses the major degradation issues affecting land resources in Queensland. Each issue is discussed in terms of how it affects the landscape, and the current environmental condition is assessed. Management actions to minimise degradation are explained, and government and community responses are discussed.



Land is used for economic purposes, such as food production. (Photo: J. Dunn, DLGP)

Condition and trend information is presented by the Natural Resource Management (NRM) regions where possible (see figure 1.4, page 1.9).
The regions are:

CY Cape York (includes Torres Strait)

NG Northern Gulf

SG Southern Gulf

DC Desert Channels

SW South West

WT Wet Tropics

MK Mackay–Whitsunday

F Fitzroy

BM Burnett–Mary

SE South East

MD Murray–Darling

DU Desert Uplands

BDT Burdekin Dry Tropics



The impacts of activities such as grazing can degrade the quality of land resources if environmental factors are not considered. (Photo: DPI)

Land use

Queensland's land resources range from land in near natural condition to land that has undergone development for a range of purposes including production, residential accommodation, recreation and transport.



Residential land use is concentrated on the eastern coast of Queensland, particularly the south-east corner. (Photo: D. Jew, EPA)

The state's rapidly increasing population creates a demand for more land development. This demand puts pressure on land currently under native vegetation or used for agriculture. The result has been a significant impact on biodiversity and a dwindling supply of good agricultural land. Inappropriate land use can lead to degradation and impacts on water quality and air.

Accurate information on land use is important for a broad range of planning and assessment activities. Catchment-scale land use maps are key datasets for predicting water quality and susceptibility to erosion and salinity. Table 4.1 summarises the principal land uses in Queensland.

Table 4.1 Land uses in Queensland

Land use	Area (km²)	Percentage of the state
Grazing	1 445 321	83.9
Conservation areas	90 550	5.2
Production forests[a]	42 816	2.5
Dryland cropping	22 540	1.3
Irrigated and other intensive cropping	4 230	0.2
Water bodies	16 234	0.9
Intensive uses[b]	6 808	0.4
Urban	947	0.1
Other[c]	95 518	5.5
Total	**1 724 964**	**100.0**

[a] Includes plantations and production native forests.
[b] Includes intensive horticulture (shadehouses, glasshouses), intensive animal production, manufacturing and industrial, services, utilities (electricity generation, gas treatment storage and transmission), transport and communication, mining, waste treatment and disposal.
[c] Includes defence, stock routes, roads and land used for non-production or environmental purposes other than that included in 'conservation areas'.

Source: Derived from Commonwealth of Australia 2002a

Land tenure

State land, leasehold land and freeholding leases cover approximately 83% of Queensland. Table 4.2 provides data on various forms of land tenure in Queensland. The area of leasehold land is decreasing, mostly as a result of conversion to freehold. The area of land acquired for state purposes has increased significantly.

Table 4.2 Land tenure in Queensland

Land tenure	1997 (km²)	2002 (km²)
Leasehold	1 153 470	1 137 600
Freeholding lease	163 180	108 560
Freehold	286 800	340 700
Protected areas	69 270	71 130
State forest, timber reserves	42 570	42 390
Other state land	11 710	26 620
Total	**1 727 000**	**1 727 000**

Source: DNRM

Grazing

Grazing, mainly by cattle and sheep, is by far the most significant land use. Land use varies from extensive grazing in western and northern areas to more intensively grazed areas closer to the coast.

Grazing leases cover large areas of native vegetation with limited grazing value. Queensland also has extensive grazing areas in woodlands and open downs where no tree clearing has occurred. Extensive grazing lands are based largely on native pastures, although large areas of predominantly buffel grass pastures are grazed in some regions. Extensive grazing lands have very limited inputs: no fertilisers, and pesticide used only to control environmental weeds.



Most grazing lands are based on native pastures but large areas of the non-native buffel grass are used for grazing in some regions. (Photo: EPA)

In higher-rainfall areas, grazing lands are more intensively managed and exotic species often replace native pastures. The area of improved pastures was estimated to be 4 455 000 ha in 1999–2000 (ABS 2001a). Inputs are usually relatively small.

Irrigated pastures, mostly associated with the dairy industry, were estimated in 1999–2000 to cover an area of 54 000 ha (ABS 2001a). Irrigated pastures have higher fertiliser requirements.

Cropping

Queensland's diverse soil types and climate support a wide variety of crops. Sugarcane farming and intensive horticulture dominate in the coastal zone, in either high-rainfall areas or irrigation areas including Maryborough, Bundaberg, Mackay and the Burdekin. Grain is grown on the Darling Downs and Western Downs and in the Central Highlands. Cotton is produced largely under irrigation and is grown close to major dams or rivers in central and southern Queensland. The inland Burnett, Dawson-Callide and Atherton Tableland are also important cropping districts.



Sugarcane farming is predominant in the state's coastal areas. (Photo: DNRM)

The area under crop is subject to variability, depending primarily on climate and markets. Table 4.3 shows the area cropped in Queensland from 1997–98 to 2000–01. The maximum area cultivated, 31 300 km² in 1999–2000, represented 1.8% of the state.

A relatively small proportion of cropped land is irrigated; ABS statistics for 1999–2000 state the area as 4940 km², or 16% of the cropped land.

Table 4.3 Area under crop in Queensland, 1997–98 to 2000–01

Year	Area (km²)
1997–98	26 840
1998–99	30 140
1999–2000	31 300
2000–01	29 550

Sources: ABS 2001a, 2002c

Mining

Mining and petroleum tenements cover 41.7 million hectares (24% of the state). Approximately 87 400 ha, or 0.05% of the state, is disturbed by current mining and petroleum activities.



Mining and petroleum activities cover approximately 0.05% of the state. (Photo: DNRM)



Cotton crops are produced primarily in irrigated areas in central and southern Queensland. (Photo: DNRM)



Native forest covers about 27% of the state's total land area. Rainforest areas, such as Mossman Gorge, account for 1% of the land area covered by native forest. (Photo: EPA)

Native vegetation and forestry

Broad forest types include open eucalypt, dense eucalypt, melaleuca, rainforest, mangrove, cypress pine and banksia. Queensland has about 46 million hectares of native forest, covering 27% of the state's total land area. Of the total forest cover, 77% is woodland, 22% is forest and 1% is rainforest. Forests are managed in various ways:

- 8% is public forest managed for multiple uses including timber production;
- 7% is in public conservation reserves;
- 4% is in other public lands;
- 61% is in leasehold land; and
- 20% is privately owned.

Land use planning policies

Queensland's 125 local governments are the principal land use planning authorities. Planning is undertaken primarily through planning schemes under the *Integrated Planning Act 1997* (IP Act). The purpose of the schemes is to seek to achieve ecological sustainability by:

- coordinating and integrating planning at local, regional and state levels;
- managing the development process; and
- managing the effects of development on environments.

State agencies provide input to land use planning in a number of ways. They advise local governments of state interests that could be adversely affected by planning schemes and that need to be considered. The extent to which state interests are considered by local governments depends on a number of factors, including whether state interests have a legislative basis and whether there is a state planning policy (SPP) applicable to the matter. State agencies have input through the integrated development assessment system (IDAS), in which various state agencies have prescribed roles—advice or concurrence—in the assessment of particular kinds of development applications in which a state interest is involved and for which the agency has a responsibility. They also have input into regional planning processes.

Currently only a small number of local governments have completed their IP Act planning schemes, but all are expected to have them completed by 30 June 2004. Statistics on the adoption of local government planning schemes are available from the Department of Local Government and Planning website, ‹http://www.ipa.qld.gov.au/plan/planSchemes.asp›.

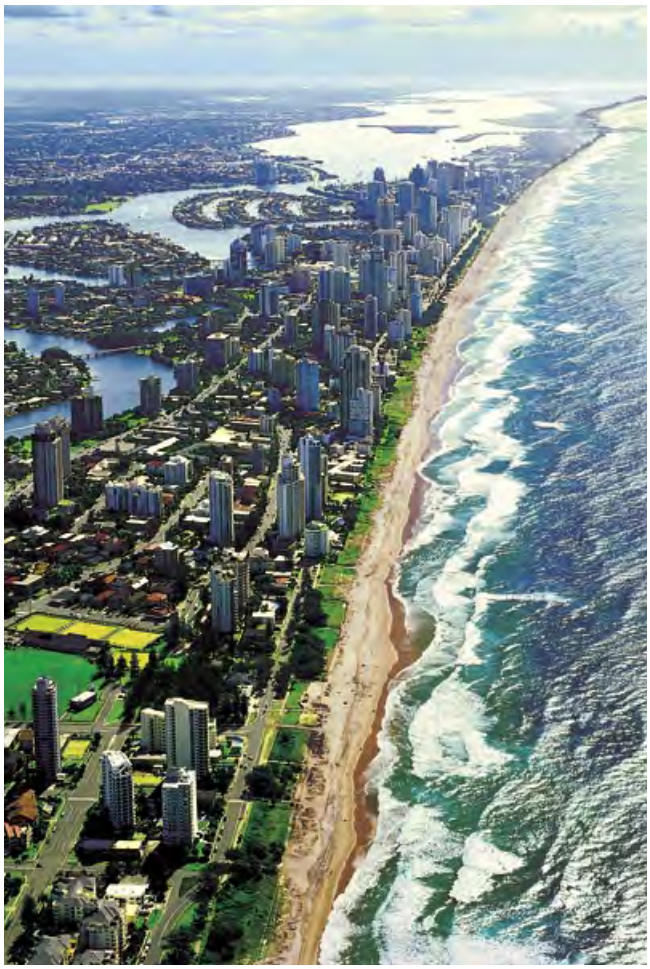
The state is responsible for the management of the leasehold estate, which accounts for approximately 66% of Queensland's total area. The use of land on leasehold areas is guided by the conditions and purposes of the lease.

Major factors affecting land use change

Increasing population and economic growth create pressures for land use change in both rural and urban areas. Coastal areas, especially between Noosa and Coolangatta, are under greatest pressure because of the need for more land for residential and urban areas (see Chapter 8, 'Human settlements').

Land uses in rural areas are responsive to markets, economics and climate. This may result in changes in the types of crops grown, or a move from cropping to grazing.

Two important issues are the need to maintain native vegetation to protect biodiversity and prevent land degradation, and the need to protect good quality agricultural land from subdivision. These issues may compete with each other when a local authority needs to decide in which direction urban expansion should proceed.



Coastal areas in south-east Queensland are under the greatest pressure for land for residential, industrial and infrastructure purposes. (Photo: DNRM)

Management of native vegetation

The Queensland Government is implementing a planning framework for the management of native vegetation across the state. The framework aims to develop a system that achieves:

- ecologically sustainable use of land;
- protection of biodiversity and other environmental and social values;
- planning certainty for landholders, industry and the community;
- prevention of land degradation caused by processes such as salinity and soil erosion; and
- protection of water quality within catchments.

The framework is based on good land management practices and aims to ensure long-term sustainable land use. Specifically, it deals with clearing of native vegetation on freehold and leasehold lands in urban and rural areas across Queensland. It has close links with a wide range of existing programs that promote sustainable land management.

The framework includes:

- legislation—the *Vegetation Management Act 1999*, which makes vegetation clearing on freehold land assessable under the IP Act, and the *Land Act 1994*, which governs vegetation management on leasehold and other state land;
- state policies for vegetation management on freehold and leasehold land, which include assessment codes for clearing;
- regional vegetation management plans, which bring together practical local experience and current scientific knowledge. Twenty-four plans are currently under development and are due for completion in the period December 2003 to June 2004. They will contain regional assessment codes for clearing, replacing the state code for the area covered by the plan; and
- community information sharing, which recognises and promotes good vegetation management practices.

Table 4.4 shows clearing rates in Queensland from 1991 to 2001 and uses to which the cleared land is put. Annual land clearing rates increased steadily until the introduction of legislation regulating clearing on freehold land in September 2000. After that date, land clearing decreased significantly. Most of the land cleared is used for pastures.

Protection of good quality agricultural land

Good quality agricultural land is a finite resource that must be conserved and managed for the longer term. The conversion of agricultural land to urban development not only takes land out of production but also places at risk the viability of remaining land as a result of reduced area and land use conflict issues. Conversion of good quality agricultural land is an issue in any area of population growth, particularly where a town or city was established as a service centre for the surrounding agricultural area.

Good quality agricultural land is determined by an assessment of its agricultural potential. State and local governments have recognised that this land is a scarce productive resource that needs protection through land use planning measures. State Planning Policy *(SPP) 1/92: Development and Conservation of Agricultural Land* provides guidance to local governments on how to protect good quality agricultural land of state and regional significance when exercising their planning powers. As it is a state interest, it must be taken into account by local governments in the preparation of their planning schemes. It is the responsibility of local governments, however, to judge the extent to which matters such as good quality agricultural land are taken into account in the determination of development applications.

Table 4.5 provides data on the conversion of good quality agricultural land in south-east Queensland. Similar data are currently not available for other areas of the state. The table shows that the conversion of good quality agricultural land is continuing and that this issue needs further attention.

Table 4.5 Conversion of good quality agricultural land (GQAL) in south-east Queensland

Local government area	Area (ha) of GQAL before development	Area (ha) of GQAL converted by:		Percentage of GQAL converted by:	
		1995	2002	1995	2002
Brisbane	26 915	9 556	10 530	35.5	39.1
NORSROC[a]	111 254	10 087	13 069	9.1	11.7
SouthROC[b]	92 152	9 282	11 167	10.1	12.1
WESROC[c]	133 195	7 394	8 539	5.6	6.4
Total SEQ region	**363 516**	**36 319**	**43 305**	**10.0**	**11.9**

[a] Northern Sub-regional Organisation of Councils (Caboolture, Caloundra, Kilcoy, Maroochy, Noosa, Pine Rivers, Redcliffe)
[b] Southern Region Organisation of Councils (Beaudesert, Gold Coast, Logan, Redland)
[c] Western Subregional Organisation of Councils (Boonah, Esk, Gatton, Ipswich, Laidley, Toowoomba)

Source: DLGP

Table 4.4 Clearing rates in Queensland and replacement land cover, 1991–2001

Replacement cover	Clearing rate 1991–95		Clearing rate 1995–97		Clearing rate 1997–99		Clearing rate 1999–2000		Clearing rate 2000–01	
	Rate ('000 ha/ year)	Percentage of state clearing total	Rate ('000 ha/ year)	Percentage of state clearing total	Rate ('000 ha/ year)	Percentage of state clearing total	Rate ('000 ha/ year)	Percentage of state clearing total	Rate ('000 ha/ year)	Percentage of state clearing total
Pasture	265.3	91.86	292.6	87.12	363.8	85.50	716.4	94.53	355.3	94.02
Crop	12.5	4.33	29.4	8.75	40.8	9.59	20.0	2.64	2.0	0.54
Forest	4.8	1.66	0.5	0.15	7.4	1.74	6.5	0.86	8.2	2.18
Mining	1.5	0.52	2.7	0.80	2.1	0.49	1.4	0.19	1.9	0.51
Infrastructure	2.4	0.83	8.2	2.44	9.9	2.33	11.5	1.52	8.9	2.36
Settlement	2.3	0.80	2.5	0.74	1.5	0.35	2.0	0.26	1.5	0.39
Total	**288.8**	**100.00**	**335.9**	**100.00**	**425.5**	**100.00**	**757.8**	**100.00**	**377.8**	**100.00**

Source: DNRM 2003

Land use mapping program

Land use data are essential for a broad range of natural resource management activities, including assessment of water quality as well as salinity and erosion risks and hazards. Such data will also contribute to future policy development to ensure that Queensland's natural resources are managed sustainably. The Queensland Department of Natural Resources and Mines (DNRM) has been working with the Commonwealth Bureau of Rural Sciences (BRS), National Land and Water Resources Audit (NLWRA) and other state agencies to develop catchment-scale land use datasets since 1999, as part of the Queensland Land Use Mapping Program (QLUMP) (Rowland et al. 2002).

The aim of QLUMP is to produce consistent and accurate baseline land use datasets as at 1999. These will facilitate monitoring of land use change and be used to prepare updated maps as required. Mapping has been completed for key catchments including the Fitzroy, Upper Condamine and Lower Balonne and is nearing completion for coastal catchments in south-east and central Queensland, including the Brisbane and Burnett. The program has recently been expanded to include the Queensland Murray-Darling Basin, the Burdekin and several coastal catchments in far north Queensland. Approximately 42% of the state either has been or is being mapped. Figure 4.1 shows the main land uses in Queensland.

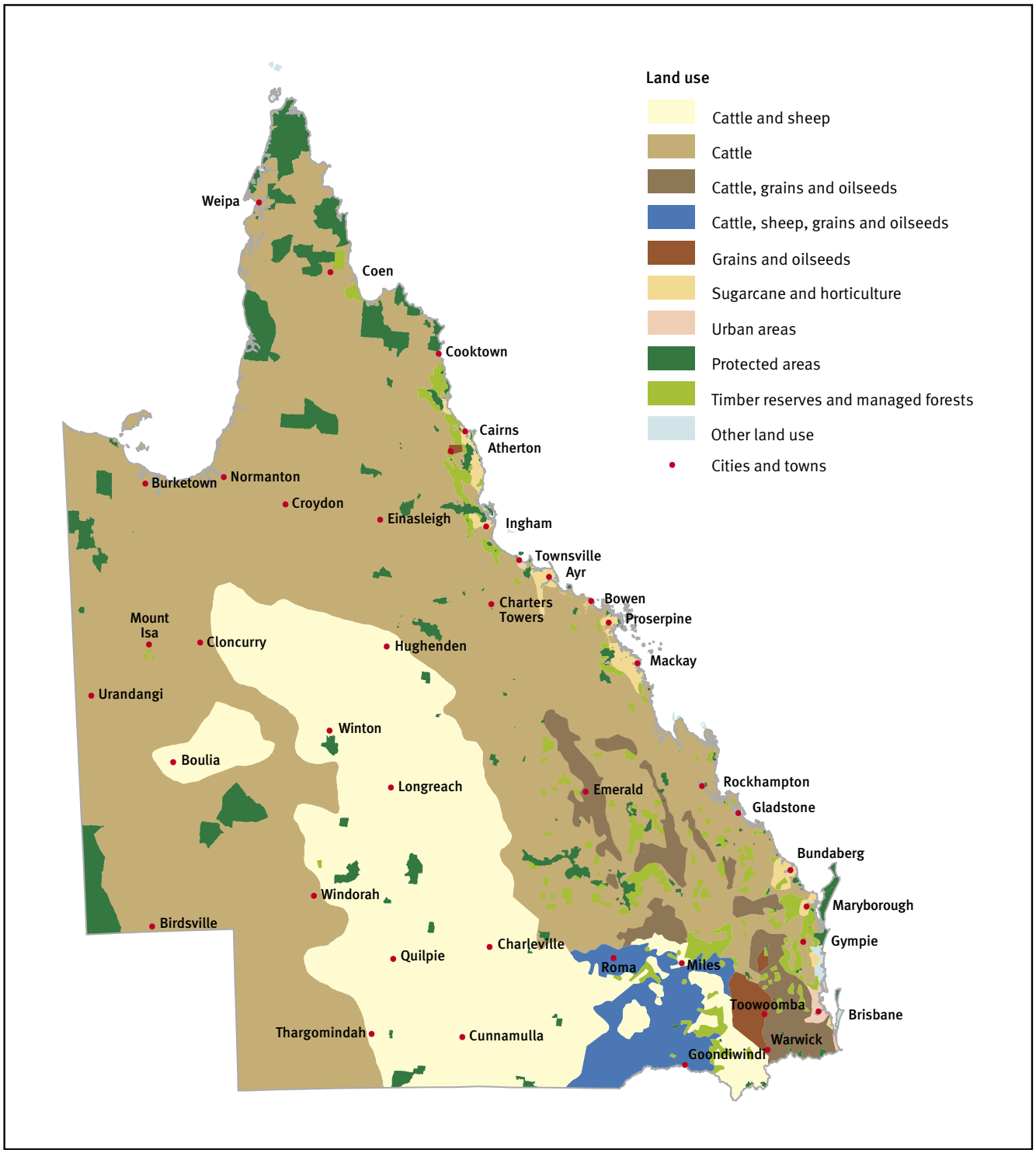


Figure 4.1 *Land use in Queensland*
Source: Land use data derived from EPA 1999 and Commonwealth of Australia 2002a



Changes in climate can affect pasture condition and industries that rely on pasture, such as cattle grazing and wool production. (Photo: DPI)

Climate variability and pasture production

Grazing is by far the major land use in Queensland. The state's extensive grazing lands support over 11.1 million beef cattle, 8.7 million sheep (ABS 2002b) and at least 20 million native herbivores such as macropods. The 2002 gross agricultural value from the meat and wool industries was estimated at $3.3 billion and represented more than 40% of total gross value from agriculture.

Climate variability and climate trends have important implications for the economic value of this sector. Pasture production is strongly affected by climate and responds to variations in rainfall, temperature, humidity, sunlight and evaporative demand on a number of time scales. Other agricultural land uses, such as cropping and horticulture, are also strongly affected by variation in these climatic elements, as are biodiversity and community wellbeing. This section discusses the effects of climate on pasture production.

Climate trends

The Bureau of Meteorology has reviewed fluctuations and trends in Queensland's climate. In terms of rainfall, the year 2002 was ranked the sixth lowest in 103 years. Maximum temperature averaged across Queensland in 2002 was the highest on record. January 2003 had the lowest January rainfall on record (that is, since ~1910) for many locations on the east coast and adjacent inland. The record maximum temperatures reduced moisture levels further, which added to the severity of the drought. These recent extremes highlight the importance of monitoring and analysing trends in climate and their implications for Queensland's natural resources.

Figures 4.2 and 4.3 show trends in some climate variables averaged across Queensland's main pastoral and broadacre cropping zone (about 60% of the state, which includes approximately 80% of domestic livestock). Significant increasing trends have been occurring in annual mean temperature and minimum temperature across this region since 1957 (figures 4.2(a) and 4.2(c)). Although there is only a small trend in maximum temperature (figure 4.2(b)), the 12-month value for 1 November 2001 to 31 October 2002 was the highest on record for the period of available daily climate data (that is, since 1957).

Rainfall averaged across Queensland's pastoral and cropping zone shows no trend (figure 4.3(a)), high variability being consistent with major climate drivers such as the El Niño Southern Oscillation. Central coastal regions have experienced severe rainfall deficiencies over the past decade.

Vapour pressure deficit (Vpd) measures the effects of humidity and temperature on evaporative demand and efficiency of plant water use. While there is no statistically significant trend in Vpd since 1957, the 12-month period 1 November 2001 to 31 October 2002 had the highest Vpd for the period of available records (figure 4.3(b)). An average annual moisture index (figure 4.3(c)) calculated for Queensland (ratio of rainfall to estimated evaporative demand) shows no significant trend, although the 12-month period 1 November 2001 to 31 October 2002 had the lowest index in the available record (that is, since 1957).

Recent research has identified the importance of inter-decadal variability in sea surface temperatures in the Pacific Ocean for variability in Queensland's rainfall. Indices representing both ENSO (El Niño Southern Oscillation) effects and inter-decadal variability explain the above-average rainfall of the 1950s and 1970s and the below-average rainfall from 1977 to 1997. Thus, care is needed in interpreting short-term trends in climate variables, such as those from the mid-1970s to the present, as these are likely to be the result of inter-decadal oscillations as well as global warming and other climate-forcing trends. Global climate models provide the capability to conduct attribution experiments to separate natural variability effects from anthropogenic effects, and this research is currently under way.

Trends in pasture production and use

The pressure on the grazed resource can best be summarised by the ratio of animals to pasture growth. Pasture growth was simulated with a model developed and validated over the past 20 years at a 5 km resolution across Queensland (figures 4.3(d) and 4.4(a)). 'Pasture use' was calculated by expressing livestock as adult beef equivalents (figure 4.3(e)) and converting to a pasture intake (figures 4.3(f) and 4.4(b)) and then dividing by pasture growth. Adult beef and dry sheep equivalents are the total weight of animals in an area divided by the normal weight of a single animal (usually taken as 400 kg for beef and 50 kg for dry sheep).

Pasture growth was calculated assuming a constant tree density and no change in pasture composition. The simulation integrates the effects of variability in climatic elements (rainfall, temperature, humidity, solar radiation and pan evaporation) on pasture growth. Historical variability in simulated pasture growth reflects mainly the variability in rainfall (figures 4.3(a) and 4.3(d)). Using this simulation approach, the most recent 12-month period (1 March 2002 to 28 February 2003) ranks as the lowest in terms of pasture growth since 1957. Simulations conducted using historical rainfall data from 1890, and average data for other climatic elements up to 1957, indicate that 2002–03 was the third lowest year on record; only the years 1902–03 and 1951–52 were lower. Historical daily climate data are currently being reconstructed back to the 1890s to allow a more accurate ranking of current conditions.

The major changes in vegetation affecting pasture productivity not included in this analysis are vegetation thickening (Burrows et al. 2002), increase in buffel grass (O'Rourke et al. 1992), tree clearing (various SLATS reports; Henry et al. 2002), and increases in herbaceous and woody weeds and other forms of land degradation (EPA 1999).

Analysis of animal numbers over time indicates that June 2001 values were approximately equivalent to the high numbers that occurred in the late 1970s (figure 4.3(e)). The retention of these high numbers in some regions, such as Dalrymple Shire, during the drier 1980s is thought to have led to increased degradation (soil erosion and weed infestation).

Other herbivores also contribute to grazing pressure. The 2002 Queensland Parks and Wildlife Service quota submission estimated 38.5 million kangaroos (macropods) for the harvest area of Queensland (~1.5 million square kilometres) in 2001. A.R. Pople (pers. comm.) estimated a lower state population of 24 million, based on more conservative extrapolation factors outside the core survey region. Based on a conversion (two macropods equivalent to one dry sheep equivalent), the estimate of 24 million macropods represents an additional grazing pressure of ~12 million dry sheep equivalents or ~1.5 million adult beef equivalents.

An average pasture use variable was calculated as an index of grazing pressure. The number of livestock over time was used to estimate annual animal intake of pasture averaged across Queensland. Pasture use was calculated as the ratio of annual pasture intake and annual pasture growth averaged across Queensland for the 12-month periods 1 November to 31 October (figure 4.3(f)) and 1 March to 28 February (figure 4.4(b)).

Intensity of pasture use during the 1960s and 1980s (figures 4.3(f) and 4.4(b)) caused degradation in various areas, such as south-west Queensland in the 1960s and north-east Queensland in the 1980s. The high pasture use rates in the early 1990s are reflected in the heavy pressure on central Queensland pastures and associated infestation by weeds such as parthenium. The period 1999 to 2001 had favourable rainfall and pasture growth across central and western Queensland and this is reflected in the lower pasture use rates (figures 4.3(d), 4.3(e) and 4.3(f)). The 2001–02 and 2002–03 summers had lower rainfall and pasture growth; hence, pasture use rates have been increasing, as a result of both below-average seasons and high stock numbers.

Anecdotal evidence suggests that substantial reductions in stock numbers have occurred in response to the emerging drought (2001–02 and 2002–03), although the reduction in grazing pressure cannot be quantified at the time of writing (March 2003). The pasture use calculation does not include grazing pressure from other herbivores such as macropods, rabbits and goats. Research is currently being done to estimate the grazing pressure resulting from these herbivores and their potential contribution to the risk of resource degradation. Thus, estimated pasture use represents a conservative estimate of actual pressure on the pasture resource.

In summary, the time series graphs show the severity of the 2002–03 drought in terms of low rainfall, high evaporative demand and low simulated pasture growth. High numbers of livestock and other herbivores (macropods) are likely to have resulted in high grazing pressure on the pastoral resource. Any reduction in animal numbers that has occurred in response to drought would have alleviated this pressure to some degree.

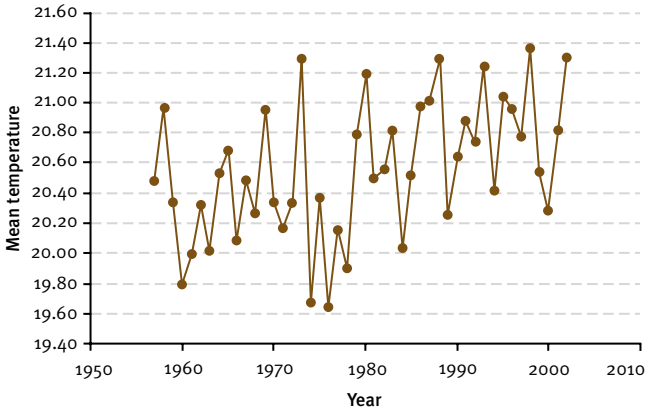


Figure 4.2(a) *Annual mean temperature (°C, 1 November to 31 October) averaged across Queensland's pastoral and cropping zone (approximately 100 million hectares and containing 80% of livestock)*
Source: DNRM

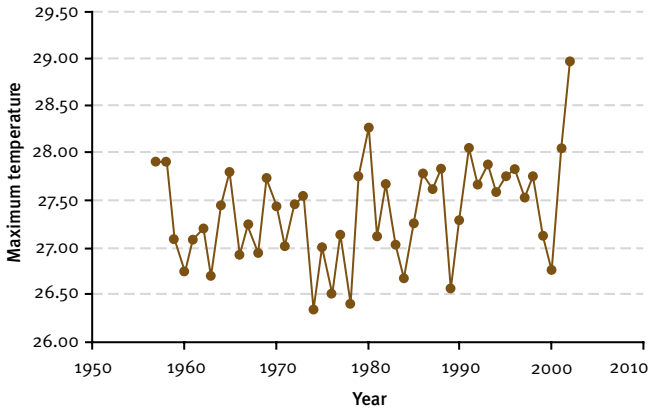


Figure 4.2(b) *Annual maximum temperature (°C, 1 November to 31 October) averaged across Queensland's pastoral and cropping zone (approximately 100 million hectares and containing 80% of livestock)*
Source: DNRM

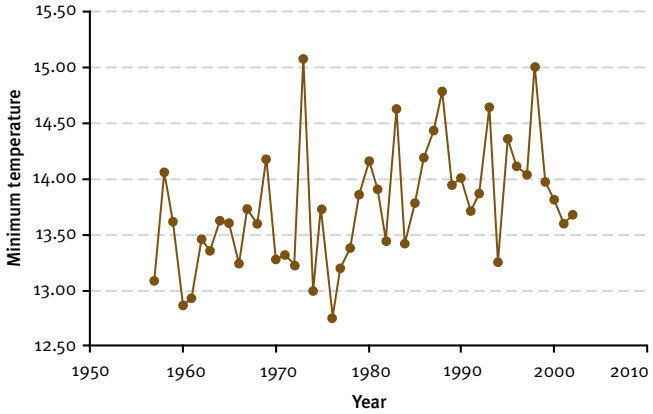


Figure 4.2(c) *Annual minimum temperature (°C, 1 November to 31 October) averaged across Queensland's pastoral and cropping zone (approximately 100 million hectares and containing 80% of livestock)*
Source: DNRM



Western grass pastures in the mulga woodlands of south-west Queensland. Mulga 'topfeed' is highly regarded as a dry season fodder resource for domestic animals. If livestock are retained for extended periods of dry weather, mulga and grass pastures may be over-used. (Photo: DNRM)

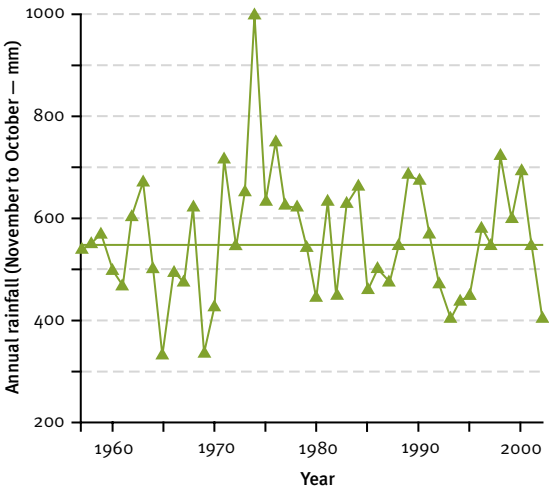


Figure 4.3(a) *Annual rainfall (mm, 1 November to 31 October) averaged across Queensland's pastoral and cropping zone (approximately 100 million hectares and containing 80% of livestock)*
Source: DNRM

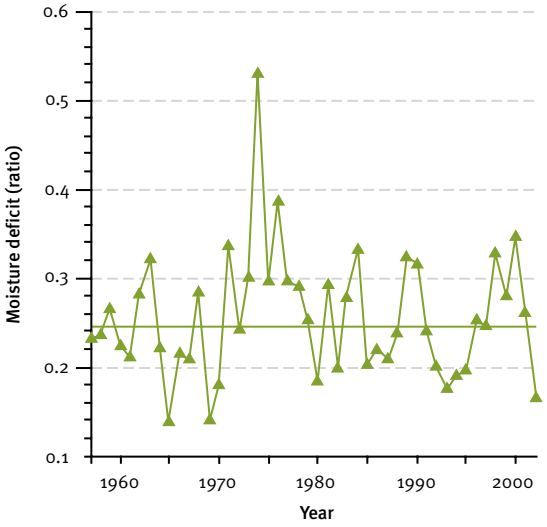


Figure 4.3(c) *Moisture index averaged across Queensland's pastoral and cropping zone (for 1 November to 31 October). An average 'moisture index' for Queensland was calculated as the ratio of average rainfall (figure 4.3a) to average evaporative demand. Average evaporative demand across Queensland was estimated by calculating a 'synthetic Class A pan' evaporation based on a multiple regression of vapour pressure deficit (figure 4.3b) and solar radiation. Synthetic_pan (mm/day) = 0.0128 + 0.225 × Vpd + 0.073 × Solar, where Vpd is vapour pressure deficit in hPa and Solar is solar radiation in MJ/m²/day (equation based on annual values)*
Source: DNRM

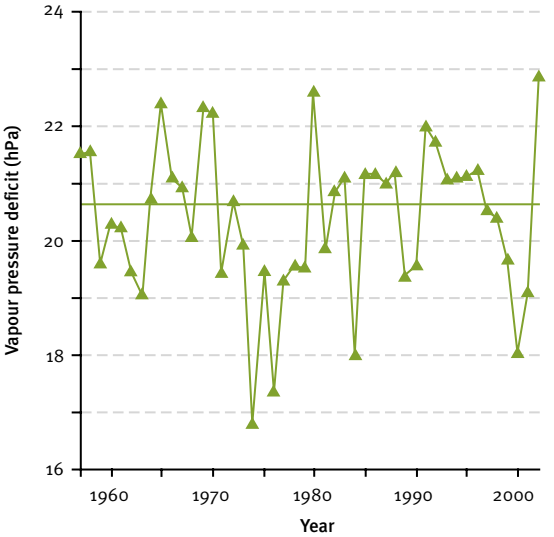


Figure 4.3(b) *Vapour pressure deficit (hPa, 1 November to 31 October) averaged across Queensland's pastoral and cropping zone. Vapour pressure deficit (Vpd) was calculated using the following formula: Vpd = VpsatTmin + 0.75 (VpsatTmax – VpsatTmin) – actual Vp, where Vpsat is saturated vapour pressure at indicated temperature (Tmin minimum temperature, Tmax maximum temperature) and actual Vp is actual vapour pressure measured at 9.00 a.m.*
Source: DNRM

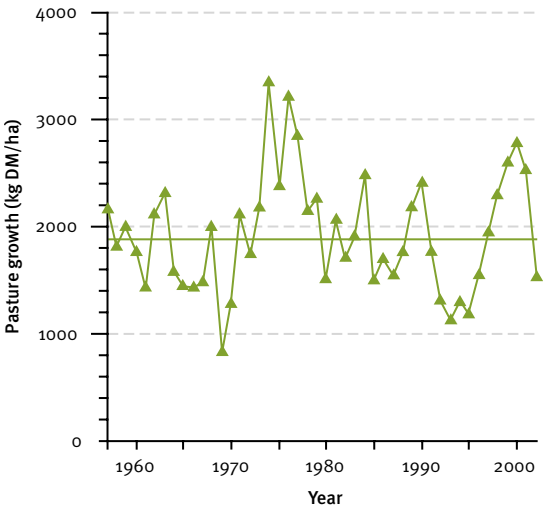


Figure 4.3(d) *Simulated annual pasture growth (kg of dry matter/ha/year) for 1 November to 31 October over the whole of Queensland (173 million hectares), using the Aussie GRASS model (Carter et al. 2000). Pasture growth is calculated from inputs of daily rainfall, temperature, humidity, solar radiation and pan evaporation. Soil characteristics, tree density and pasture composition were held constant for the purposes of the simulation based on estimates in the mid-1990s.*
Source: DNRM

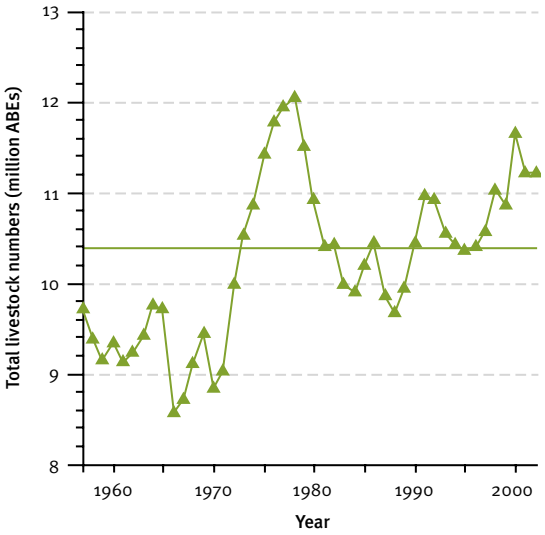


Figure 4.3(e) *Total livestock numbers expressed as adult beef equivalents (ABEs) for the whole of Queensland (173 million hectares) derived from ABS data. Sheep numbers have been converted to adult beef equivalents (Stone, G.S., pers. comm.). Census data were collected up to 1997 and again in 2001. Surveys were conducted for 1998, 1999 and 2000. Animal numbers shown for 2002 were estimated as the same as 2001 solely for the purposes of estimating potential pasture use. Source: DNRM*

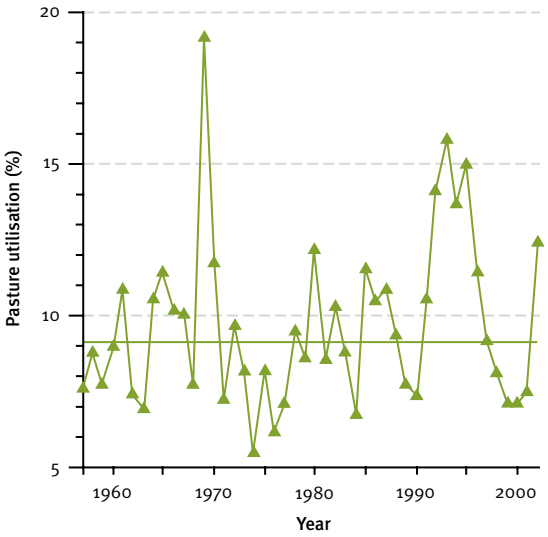


Figure 4.3(f) *Pasture use (percentage) calculated for the whole of Queensland (173 million hectares). Pasture use was calculated as the ratio of estimated annual intake to simulated annual pasture growth for the 12-month period 1 November to 31 October. Both intake and pasture growth were averaged across Queensland before the ratio was calculated. The most recent reported livestock numbers were for June 2001; hence, percentage pasture use for 2002 represents a potential pasture use if stock had been retained. Source: DNRM*

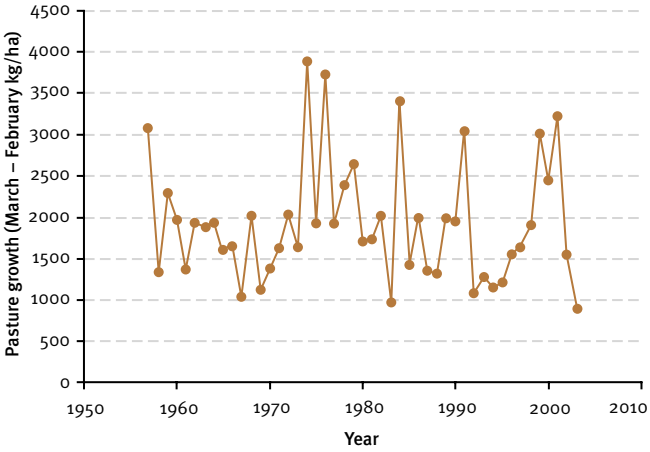


Figure 4.4(a) *Simulated annual pasture growth (kg/ha/year) for 1 March to 28 February over the whole of Queensland, using the Aussie GRASS model (Carter et al. 2000). Pasture growth was calculated from inputs of daily rainfall, temperature, humidity, solar radiation and pan evaporation. Soil characteristics, tree density and pasture composition were held constant for the purposes of the simulation based on estimates in the mid-1990s. Source: DNRM*

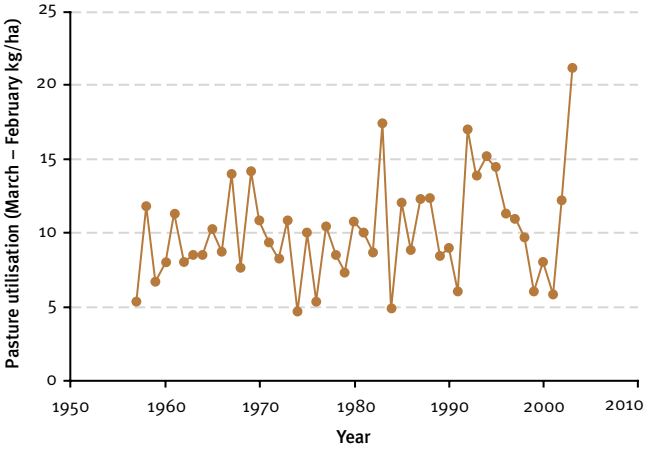
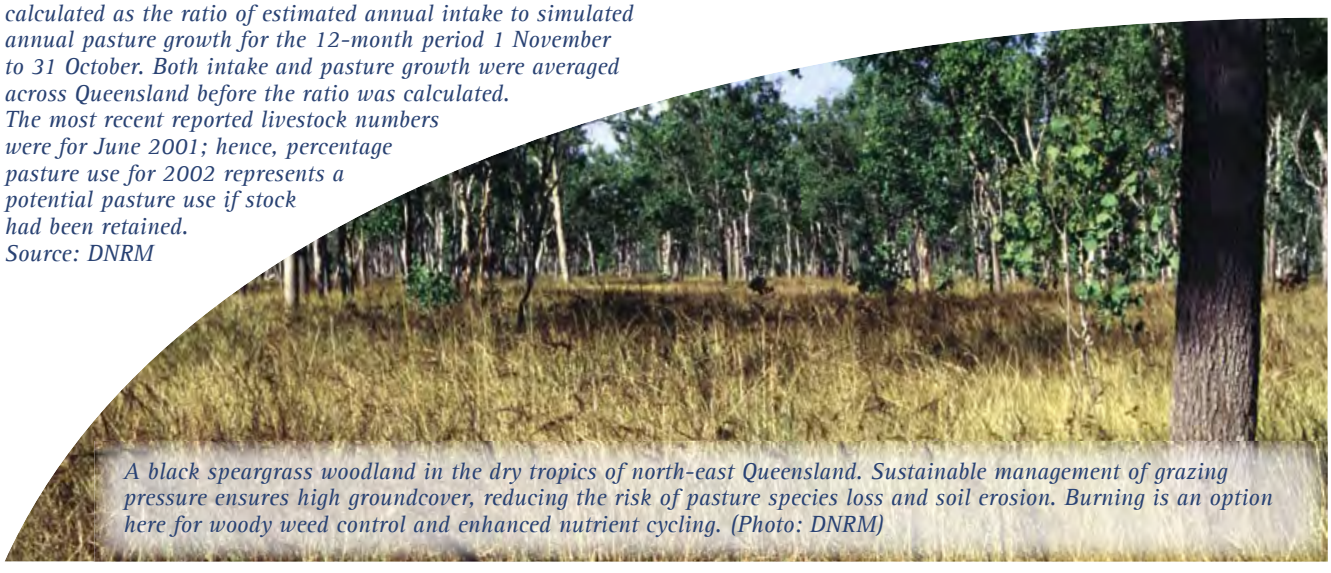


Figure 4.4b *Pasture use (percentage) calculated for the whole of Queensland. Pasture use was calculated as the ratio of estimated annual intake to simulated annual pasture growth for the 12-month period 1 March to 28 February. Both intake and pasture growth were averaged across Queensland. Source: DNRM*



A black speargrass woodland in the dry tropics of north-east Queensland. Sustainable management of grazing pressure ensures high groundcover, reducing the risk of pasture species loss and soil erosion. Burning is an option here for woody weed control and enhanced nutrient cycling. (Photo: DNRM)

Mining disturbance

Summary

The total area covered by mining and petroleum tenements in Queensland is 41.7 million hectares. Mining and quarrying activity on those tenements and the associated level and value of production of metallic and fuel minerals continue to grow, bringing increased potential for land use conflicts and environmental impacts.

The area of land disturbed and rehabilitated by mining and petroleum activities is currently approximately 87 400 ha and 29 800 ha respectively, with 13 190 ha disturbed and 6750 ha rehabilitated since 1999. Government expenditure on rehabilitation of abandoned mines to June 2002 was $15 million.

A new environmental regulatory regime for mining under the *Environmental Protection Act 1994* (EP Act) is administered by the Environmental Protection Agency (EPA). Amending legislation to transfer regulation of petroleum and gas activities to this Act will commence in 2004.

Industry is increasingly adopting minimum impact strategies on sites regarding environmental management planning and operational practices, and supports a comprehensive mine rehabilitation research program.

Description

Queensland has extensive mineral and energy resources, annual production contributing $9.6 billion, or 10.2%, to gross state product and generating $6 billion in export earnings and $463 million in royalty returns.

While the area of current mining and petroleum activities is geographically widespread, there can be significant local impacts, such as reduction in land capability, reduced land use potential, effects on landform stability, immediate and long-term land contamination and off-site discharges.



The number of mining, petroleum production and quarrying activities continues to increase in Queensland. (Photo: DNRM)

Pressures

The value and level of production of metallic and fuel minerals continue to grow with increases in the number of mines, mining tenements, quarries and producers of minerals and petroleum products in Queensland. These increases have caused changes in the extent and nature of land disturbances caused by different types of mining and petroleum extraction. Underground mining by tunnels and shafts typically causes minimal surface disturbance, although long wall coalmining can cause locally significant land subsidence. Process wastes (such as tailings dams and sulfidic waste stockpiles) associated with underground metalliferous mining can cause significant land contamination. Surface mining methods common in open-cut coalmining and mineral sands dredging can cause extensive land disturbance, land contamination and potential pollution of waterways. Mining of bauxite and sand, in particular, has historically had impacts on extensive areas of natural vegetation and changed soil profiles, topography and drainage patterns. Petroleum and gas pipeline developments can cause locally significant impacts through clearing of seismic lines and land contamination at drill sites and at processing facilities.



A DNRM officer takes a GPS reading at the location of a small opal mine. (Photo: DNRM)

Condition and trends

The area of land disturbed and rehabilitated by mining and petroleum projects over the period 1999–2002 is approximately 87 400 ha and 29 800 ha respectively (table 4.6, page 4.14). Coalmining projects, concentrated in the Bowen and Moreton basins and centred on Emerald and Ipswich respectively, have disturbed in the order of 40 000 ha and rehabilitated 8000 ha. The area of land disturbed by metallic minerals and sand mining is approaching 39 000 ha and the area rehabilitated is 14 000 ha. The area of land disturbed by mining activities over the past three years is approximately 13 190 ha, while the area rehabilitated is approximately 6750 ha.

Small mining activity (of opal, sapphire, alluvial gold, dimension stone, clay etc.) causes locally significant land disturbance, often in environmentally fragile arid areas.

Petroleum and gas activities have been centred in south-west Queensland and near Roma and Surat. Land disturbance caused by cleared seismic lines has historically been the most significant impact and can remain evident for the longer term. In future, significant land disturbance is likely to be caused by coal seam gas developments in the Bowen and Surat basins, particularly around Wandoan, Moura and Moranbah, often associated with coalmining.

Responses

Regulatory

Environmental regulation of the mining industry was transferred from the Department of Mines and Energy under the *Mineral Resources Act 1989* to the EPA under the EP Act.

Environmental harm caused by mining activities on mining tenements is now authorised through the conditions of environmental authorities issued under the EP Act for either standard (low-impact) or non-standard (high-impact) mining activities.

Conditions of rehabilitation outcomes and standards to be achieved during the operational and decommissioning stages of mining projects

Financial assurances (previously termed security deposits), based on third party costs (cost to government) to cover the cost of rehabilitation of land disturbed by mining activities, are now required as an authority condition. A new Petroleum and Gas Bill, together with transfer of environmental regulation of petroleum and gas activities to the EP Act, is due for completion in 2004.

The EPA has commissioned a detailed compliance evaluation and inspection program to ensure compliance with regulatory requirements. The program relies on annual compliance evaluations of high-risk projects, six-monthly compliance investigations of medium-risk projects and random compliance inspections of low-risk projects. These may be supplemented by industry sector and catchment audits.

Approximately 100 of the 20 000 abandoned mines in Queensland have been assessed as in need of rehabilitation. Expenditure on abandoned mines to June 2002 was $15 million, and programmed expenditure for 2003 is $5 million.

The State Government is committed to coordinating development of a statewide policy for the management of abandoned mine sites, including identification, risk assessment and prioritisation for rehabilitation.



A rehabilitation strategy for the historic Mount Morgan mine site to manage environmental impacts and heritage values is being developed: Mundic West seepage collection sump in the foreground and Upper Works area in the background. (Photo: DNRM)

Industry

The mining industry has introduced the Australian Industry Code for Environmental Management, to which a number of the major Queensland mining companies are signatories.

Signatories to the code are committed to:

- accepting environmental responsibility for all their actions;
- strengthening relationships with the community;
- integrating environmental management into the way they work;
- minimising the environmental impacts of their activities;
- encouraging responsible production and use of products;
- continually improving environmental performance; and
- communicating environmental performance.

Industry is increasingly adopting minimum impact environmental management strategies. These include:

- greater use of existing tracks and reduced blade clearing for exploration drilling and seismic lines;
- greater emphasis on selective material handling and hydrological and geotechnical stability in landform design and construction;
- increasing commitment to establishing self-sustaining vegetation covers and defining scientifically proven rehabilitation success criteria; and
- greater recognition of the importance of considering post-mine land management and maintenance liability in setting rehabilitation objectives.

Current industry-sponsored research is focused on tailings management, control of acid mine drainage, ecosystem reconstruction, pasture and native species establishment and management, defining rehabilitation success criteria, and landform design and stability issues.



Aldershot Smelter, near Maryborough. A containment pit is being lined with impervious clay to capture heavy metals from the smelter. (Photo: DNRM)

Table 4.6 Area of land disturbed and rehabilitated by mining projects in Queensland, historical and 1999–2002

Type of project	Number of projects	Total area disturbed, historical (ha)	Total area rehabilitated, historical (ha)	Total area not rehabilitated, historical (ha)	Area disturbed 1999–2002 (ha)	Area rehabilitated 1999– 2002 (ha)
Coal	27	39 191	7 608	31 583	5 958	2 379
Bauxite	2	14 520	6 260	8 260	1 800	1 860
Gold	55	11 757	3 894	7 862	1 858	1 525
Salt	1	6 812	6 812	0	0	0
Limestone	21	5 591	1 323	4 268	146	333
Mineral sands	1	3 737	870	2 867	–	–
Base metal	9	2 360	538	1 822	1 943	215
Phosphate	1	649	609	40	649	40
Copper	11	609	479	129	68	44
Silica	4	442	241	200	43	15
Clay	16	358	312	46	73	21
Magnesium	1	319	273	46	27	6
Opal	54	202	137	65	178	118
Oil shale	1	171	139	32	181	32
Tin—alluvial	7	144	14	130	2	1
Gold—alluvial	20	142	14	128	84	68
Sapphire	8	124	101	24	44	42
Gem	4	64	47	16	22	9
Nickel	1	46	31	15	0	15
Dimension stone	12	39	34	5	7	1
Kaolinite	2	29	12	17	56	0
Diatomite	2	19	11	8	13	6
Bentonite	1	17		17	17	11
Gypsum	1	12	2	10	12	10
Aggregate	1	5	5	0	5	0
Dolomite	2	4	2	2	2	2
Garnet	2	1	1	1	0	0
Cobalt	1	0	0	0	0	0
Total	**268**	**87 364**	**29 769**	**57 593**	**13 188**	**6 753**

Source: Survey data provided by DNRM, September 2002



Rehabilitation at Norwich Park coalmine. Topsoil replacement and revegetation of mined areas is mining industry best practice, and helps to reduce erosion and provide fauna habitat. (Photo: BMA Coal)

Salinity

Summary

The area of saline land in Queensland was assessed as 48 000 ha in 2000, increasing to 107 000 ha in 2002. Unless urgent action is taken to reverse rising watertable levels by the planting of deep-rooted native trees, selection of suitable farming systems and application of engineering solutions, about 3.1 million hectares of land in Queensland could be saline by the year 2050.



An estimated 3.1 million hectares of land in Queensland could be saline by 2050. (Photo: DNRM)

Description

Soil salinity involves excessive levels of soluble salts in the root zone, affecting normal plant growth and development. When the electrical conductivity of saturated soil (ECe) exceeds 4.5 deciSiemens per metre (dS/m), that soil is said to be saline. Plants have varying salt tolerances, however, and soil salinity must be considered in the context of a particular crop or vegetation type at risk.

The National Land and Water Resources Audit reported in 2000 that a total of 48 000 ha of land was estimated to be affected by salinity in Queensland (Commonwealth of Australia 2001a). However, the Australian Bureau of Statistics recently reported that the current area of saline land in Queensland is 107 000 ha (ABS 2002a). This increase in area is attributable mainly to landholders' greater understanding or recognition of salinity. If no preventive measures are taken, the saline area is predicted to increase to about 3.1 million hectares by the year 2050. Table 4.7 shows the key assets that are potentially threatened by salinity.

Table 4.7 Key assets located in the areas of dryland salinity hazard in Queensland

Asset	By the year 2050
Agricultural land (ha)	2 600 000
Remnant vegetation (ha)	92 000
Ramsar wetlands (ha)	635
Important wetlands (ha)	25 600
Streams (km)	1 800
Roads (km)	12 000
Rail line (km)	15 000

Source: Commonwealth of Australia 2001a

Pressures

Land use activities contribute to the development of salinity. Dryland salinity is generally caused by rising saline groundwater after clearing of deep-rooted vegetation. It can also be caused by the inappropriate siting of infrastructure such as roads and drainage channels, where these alter the local hydrology and promote ponding and rising watertables. Irrigation salinity is caused by repeated and long-term irrigation with slightly saline water or by the infiltration of excessive irrigation water to the watertable. In the latter case, the rising watertable brings salt towards the root zone or soil surface.

Condition and trends

These pressures are increasing, leading to an accelerating rise in the watertable in most of Queensland's irrigated areas (table 4.8).

Table 4.8 Watertable depth in some irrigation areas

Irrigation zone	Watertable depth (m from the surface)		
	1990	1995	2000
Mareeba-Dimbulah	5.0	4.5	2.5
Burdekin River	6.0	5.0	2.0
Emerald	8.5	4.0	0.5
Bundaberg	3.0	2.0	1.0
Lower Mary River	2.0	1.5	0.5

Responses

Soil salinity usually builds up over long periods. Problems may appear long after the causes started. Similarly, management responses rarely produce immediate improvements.

A combination of agronomic solutions (for example, revegetation with deep-rooted plants and selection of appropriate crops, such as beetroot in the Lockyer Valley) and engineering solutions (such as surface or subsurface drainage, groundwater pumping and more efficient irrigation systems) is often required to effectively minimise and potentially reverse the expansion of salinity.

Natural resource management issues are being dealt with under the provisions of the *Vegetation Management Act 1999* and the *Water Act 2000*. Numerous initiatives have been implemented with Commonwealth and state funding to combat the problem of dryland salinity in Queensland. These include projects funded through the Natural Heritage Trust (NHT) fund, the National Action Plan for Salinity and Water Quality (NAPSWQ), the National Landcare Program, and Land and Water Australia (LWA).

Case study: Landcare groups tackle salinity

The Rosalie Landcare group of Brymaroo catchment in the Darling Downs, located 20 km north of Jondaryan, has contributed greatly to knowledge about salinity management in Queensland. With the help of DNRM and The University of Queensland, the group found that planting 200 ha of trees at 400 trees/ha reduced recharge in the area by 90%, leading to a drop of the watertable by about 2 m in most of the salt-affected area. Salt-tolerant lucerne has been planted in some areas. Less saline groundwater from the up-slope areas has been used for irrigation and this alone has lowered the groundwater level by about 3 m. The photograph shows the typical salt scald that can develop in grazing lands.



Salt scald developed after clearing of deep-rooted native trees and prolonged land use for grazing (Photo: DNRM)

Summary of condition and trend indicators

Salinity

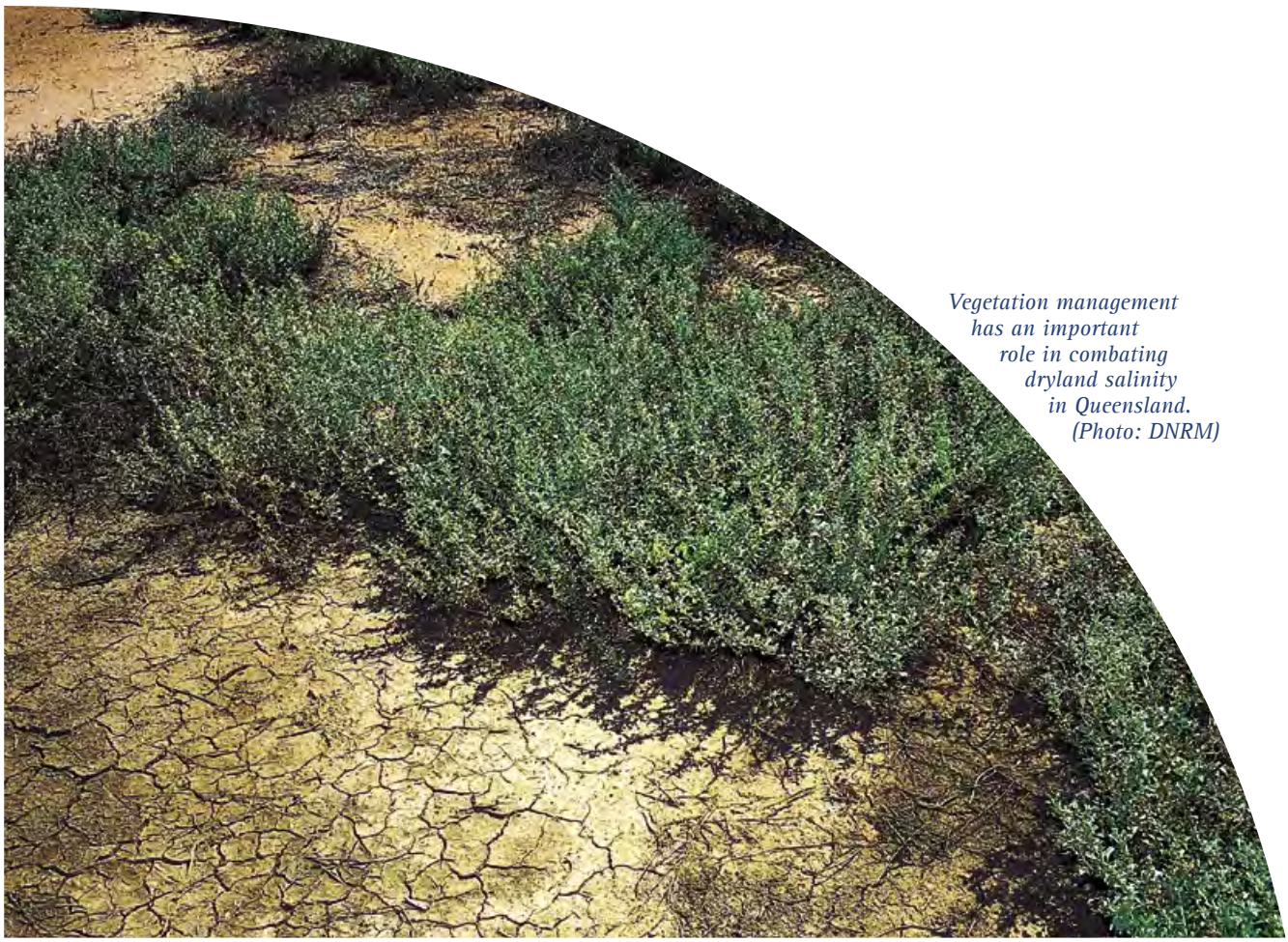
Indicator	NRM regions										
	CY	NG	SG	DC	WT	MK	F	BM	SE	MD	BDT
Area affected by dryland salinity	?	▼	?	▼	?	▼	▼	▼	▼	▼	▼
Area affected by irrigation salinity	X	▼	X	X	?	▼	?	▼	▼	?	▼
Watertable depth (irrigated areas only)	X	▼	X	X	X	X	▼	▼	X	▼	▼

Key to condition:

- Moderate
- Poor
- Not assessed

Key to trend:

- ▼ Degrading
- ▲ Improving
- ? Uncertain
- X Not assessed



Vegetation management has an important role in combating dryland salinity in Queensland. (Photo: DNRM)

Water erosion

Summary

Water erosion is a widespread problem in parts of Queensland where intense rainfall is a feature of the climate. Both rural and urban areas are at risk. Erosion reduces land productivity and significantly affects water quality. When soil is eroded, nutrients, fertilisers or pesticides present in the soil are removed as well.

Major erosion events occur spasmodically. To control water erosion, the use of land that has a high erosion risk should be avoided. Adequate levels of protective cover must be maintained and runoff must be managed. Considerable gains have been made in adopting these practices, but the task is far from complete.

Description

High-intensity rainfall, especially during summer, creates a serious risk of erosion by water in Queensland. Vulnerable land may endure unsustainable soil loss that has serious impacts on both future productivity and off-site effects.

Hill slope erosion (sheet and rill erosion) occurs in all areas. Susceptibility depends on rainfall erosivity, soil erodibility, length and steepness of slope, and land use. Gully erosion affects soil productivity, restricts land use and can threaten roads, fences and buildings. Stream bank erosion during flooding is widespread. The streams at highest risk are those where riparian vegetation has been removed. Floodplains may also be susceptible.

When soil is eroded, nutrients, fertilisers or pesticides present in the soil are also removed. Eroded soil may not have a fast track to streams. It can be deposited where there is a reduction in slope, in sediment traps, along contour banks, or in grassed waterways, dams or wetlands. Heavier soil particles are deposited first, while finer colloidal clay particles may remain in suspension. Soil removed by gully erosion, especially finer colloidal clay, may be transported directly into streams.

Three principles should be considered in connection with the control of water erosion:

- land should be used in accordance with its capability;
- the soil surface should be protected by some form of cover; and
- runoff should be managed to ensure that concentrated flows do not result in erosion.

While erosion is relatively simple and economical to control in some situations, erosion control is difficult in many cases. The control of severe gully and stream bank erosion in marginal land can be technically difficult and hard to justify economically. It is essential, therefore, that land be managed in a way that avoids the development of erosion.



Contour banks and waterways combined with stubble management practices provide effective control of soil erosion in upland cropping areas. (Photo: DNRM)



Eroded soil from land cleared for urban development (left) led to the accumulation of sediment in the gully at the foot of the slope. (Photo: EPA)

Pressures

A number of potential land management pressures can accelerate water erosion rates.

Land clearing

The susceptibility of cleared land to erosion by water depends largely on how the land is managed following clearing.

Grazing

Maintenance of surface cover is the key to erosion control in grazing lands. The ideal stocking rate is flexible, stock numbers being matched to available feed. Pastures come under greatest pressure during extended dry periods.

Cultivation

The maintenance of surface cover is also the key to erosion control in cropping areas. The level of protection varies according to the type of crop and the stubble it provides. Recent drought conditions have resulted in extensive areas of cultivation with minimal cover. Dry conditions prevented crop planting, and low yields resulted in minimal stubble cover. A phasing-out of the extension service by state soil conservation officers may be slowing the adoption of runoff control measures, such as the use of contour banks and strip cropping.

Urban development

The amount of land vulnerable to erosion during the development phase of new urban residential and industrial areas has increased. Rural residential blocks or hobby farms are at risk of erosion when they are overgrazed.

Condition and trends

An indicator of the amount of erosion that may have occurred over a period is an assessment of the erosivity of the rainfall received during that period. Modelling by the National Land and Water Resources Audit has produced data for the 76 catchments in Queensland.

Because of the episodic nature of erosion events, it is preferable to monitor progress in the adoption of erosion control practices rather than attempt to measure actual amounts of soil loss. The summary table on page 4.19 indicates that there is a general improvement in the adoption of erosion control measures in cropping lands. In grazing lands, however, surface cover has been severely reduced in areas affected by the widespread drought.

Responses

A variety of programs are available to assist in the implementation of measures to control erosion by water. These include the Natural Heritage Trust, Integrated Catchment Management and Sustainable Farming Systems projects. Landholders are being encouraged to adopt environmental management systems (EMSs) on a voluntary basis. These can be based on best management practices and codes of practice, developed with input from industry and the community.

A project aimed at identifying the areas most at risk from soil erosion is being carried out by DNRM. The process is similar to that used in the National Land and Water Resources Audit, but involves the use of a more detailed analysis of rainfall and soil erodibility factors.

The key to managing grazing lands to avoid erosion by water is maintenance of adequate levels of pasture cover on the soil surface. Grazing practices are highly variable. In some cases, pasture cover reaches satisfactory levels only during a period of good seasons. Some degraded areas never achieve satisfactory levels.

Significant gains have been made in erosion control in cropping lands since the problem became apparent in the 1940s. Many areas of very steep land have been returned to pasture for economic reasons. Surface cover levels have been greatly improved by the adoption of conservation cropping measures. However, soil loss in cropping lands is still unacceptable.

The main mechanisms used to counter water erosion in urban areas are community and local government catchment management plans and stormwater management plans. The urban stormwater plans are a legislative requirement under the *Environmental Protection (Water) Policy 1997*. Local community action, such as riverbank restoration, is an important additional means of reducing erosion in urban areas.

Case study: Green cane harvesting and trash blanketing

Traditionally, sugarcane was burnt before harvesting and very little crop residue (referred to as 'trash') remained on the surface to provide protection from water erosion. Under these conditions, erodible soils and steep slopes used for canegrowing had average soil losses as high as several hundred tonnes of soil per hectare per year. The productivity of some of these areas was reduced to such an extent that sugarcane could no longer be produced economically. Such high losses of soil and nutrients also had significant impacts on downstream areas.



Burning cane prior to harvest results in minimal trash for erosion protection. (Photo: DNRM)



Harvesting green cane leaves a layer of trash on the soil surface for protection against erosion. (Photo: DNRM)

In the 1980s, harvesters capable of cutting green (unburnt) cane came into use. Where farmers cut green cane, the resulting layer of trash left on the soil surface virtually eliminates soil loss during the growth of ratoon crops. There is a period of vulnerability to water erosion when cane is taken out of production after three to four years of ratooning. The use of ratoon crops or minimum tillage practices following the final harvest minimises the erosion risk during this period.

Farmers' adoption rates of green cane harvesting are as high as 94% in the far northern sugar growing areas. The rate of adoption is lower in southern areas (58%), mainly because the cooler soil conditions under a trash blanket slow crop growth.

Other environmental and economic benefits of green cane harvesting include improved air quality, reduced weed growth (and herbicide use), improved fertility and biological condition of the soil (reducing the need for fertiliser in the longer term), reduction in the amount of water required for irrigation and reduced fuel use.



Programs such as Grass Check emphasise the importance of maintaining surface cover to prevent erosion. (Photo: DPI)

Summary of condition and trend indicators

Water erosion

Indicator	NRM regions												
	CY	NG	SG	DC	SW	WT	MK	F	BM	SE	MD	DU	BDT
Pressure indicators													
Use of crops that provide insufficient surface cover	NR	NR	NR	NR	NR	–	–	▼ sn, cp, mb, wrs	–	–	▼ sn, cp, mb, wrs, dct	NR	–
Condition indicators													
Area of land affected by gully erosion	X	X	X	X	X	X	X	X	X	X	X	X	X
Area of cultivation with adequate protection	NR	NR	NR	NR	NR	▲	▲	▲	▲	▲	▲	NR	▲
Area of grazing land with average annual soil loss exceeding tolerable levels	X	X	X	X	X	X	X	X	X	X	X	X	X
Response indicators													
Cropped land with reduced/zero tillage practices	NR	NR	NR	NR	NR	▲	▲	▲	▲	▲	▲	NR	▲
Cropped land protected by contour banks	NR	NR	NR	NR	NR	–	–	▲	–	–	▲	NR	NR
Contour bank maintenance	NR	NR	NR	NR	NR	▼	▼	–	▼	▼	–	NR	NR
Cropped land protected by strip cropping	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	–	NR	NR

Key to codes: m = mulga feeding; sn = sunflower; cp = chickpeas; mb = mung beans; wrs = wide row sorghum; dct = dryland cotton

Key to condition:

- Good
- Moderate
- Poor
- Not assessed

Key to trend:

- ▼ Degrading
- ▲ Improving
- ? Not clear
- – No change
- X Not assessed
- NR Not relevant

Wind erosion

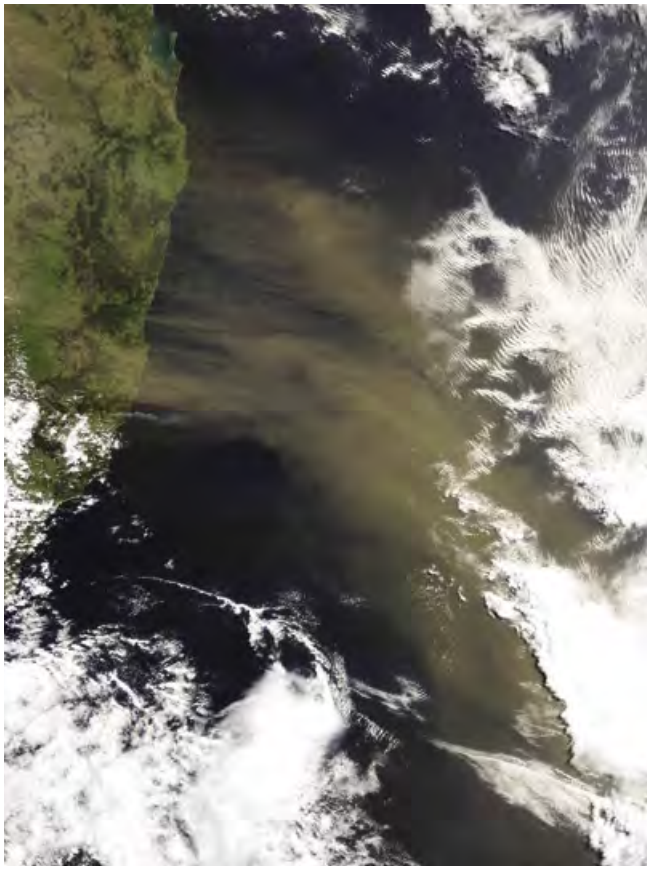
Summary

The Dust Storm Index (DSI) is used to measure wind erosion intensity and frequency across Queensland. The long-term average DSI (1960 to 2001) is used to categorise wind erosion activity for the different NRM regions across the state in the periods 1992–95 and 1998–2001. Climatic conditions have a major effect on broadscale wind erosion, while land use pressures have an effect at the local and regional scale.

Temporal patterns of wind erosion in Queensland are related to drought and the El Niño Southern Oscillation (ENSO), measured by the Southern Oscillation Index (SOI). The years 1992–95 were a period of drought, negative SOI and high wind erosion activity, while the years 1998–2001 were a period of higher rainfall, positive SOI and reduced wind erosion activity. The recent 2001–03 drought brought conditions that were characterised by significant wind erosion events. Land use pressures contributing to wind erosion include overgrazing by livestock, grazing pressure from kangaroos and rabbits, and land clearing.

Description

Wind erosion is an important land degradation process in Queensland's semi-arid and arid lands. It is a highly episodic process, which operates over large areas (approximately half of the state). The timing, intensity and distribution of wind erosion all change in response to changing environmental conditions (including climate, vegetation cover and soil erodibility), as well as changing rural land use.



Satellite image of the 23 October 2003 dust storm passing out to sea from eastern Australia (Photo: NASA)

Climatic conditions have a major influence on broadscale wind erosion as most dust storms are associated with the easterly passage of frontal systems across the continent. Dust can be entrained by hot pre-frontal northerly winds, post-frontal southerlies or frontal westerlies (Sprigg and Wasson 1982). These weather systems are prevalent in Queensland during the late spring and early summer, which is the main dust storm season (McTainsh and Leys 1993).

Pressures

A number of land use pressures can accelerate wind erosion rates. Grazing of protective vegetation can expose soils to erosion, and trampling by stock can disturb protective soil crusts. Tree clearing can lead to increased wind erosion rates by exposing soils. Agricultural activities can accelerate wind erosion by reducing protective grass cover, and cultivation of soils can increase their erodibility.



Tree clearing can expose soils and lead to increased wind erosion. (Photo: DNRM)

Condition and trends

Land condition is represented here in two forms: in maps of wind erosion activity (measured by DSI), and in a table showing land condition and trend within each NRM region. Spatial patterns of wind erosion are examined for the periods 1992–95 and 1998–2001, and land condition is assessed in relation to long-term averages (1960–2001). In the years 1992–95 rainfall was generally low, and in 1998–2001 rainfall totals were higher.

The 1992–95 pattern of wind erosion (figure 4.5) is similar to the long-term 1960–2001 pattern, but with much higher levels of activity associated with the generally dry conditions. The greatest increases in erosion were in the dry south-west of the state around Thargomindah and Birdsville and in a small area around St George on the New South Wales border. The Mulga Lands, incorporating the Charleville–Cunnamulla area, experienced a significant reduction in wind erosion, which may be related to expansion of woody weeds in this area.

The summary of condition and trend indicators represents land condition within NRM regions in the period 1992–95. In the South West, Desert Channels and Murray–Darling NRM regions, land had deteriorated in relation to the long-term condition. The coastal and Cape York NRM regions are not major wind erosion regions.

During the higher-rainfall period, 1998–2001, vegetation cover was moderate to high (DNRM 2002), grazing pressure was reduced and overall wind erosion activity was low. Figure 4.6 shows that the reduction in wind erosion in the south-west was patchy, and in the area around St Lawrence there was actually increased erosion. Wind erosion in the Birdsville area was reduced to <5% of the 1992–95 DSI level, whereas in the Thargomindah area erosion continued to be moderately active (at 39% of the 1992–95 level). These patterns are explained partly by land use changes. The summary table shows that land condition of the main wind erosion NRM regions, Desert Channels and South West, was improving and above average. Land condition in the Fitzroy and Burdekin Dry Tropics NRM regions is deteriorating and at or below average condition.

Responses

The overall trend of increasing environmental awareness among rural landholders (private and public), as well as the community as a whole, is likely to have a positive effect on land condition. Examples of this awareness include landholders' increasing membership of Landcare groups and catchment committees, and a trend towards the employment of environment officers by most of the large pastoral companies.

A proposed DustWatch network of volunteer wind erosion observers could improve the spatial resolution of wind erosion measurements and increase public awareness.

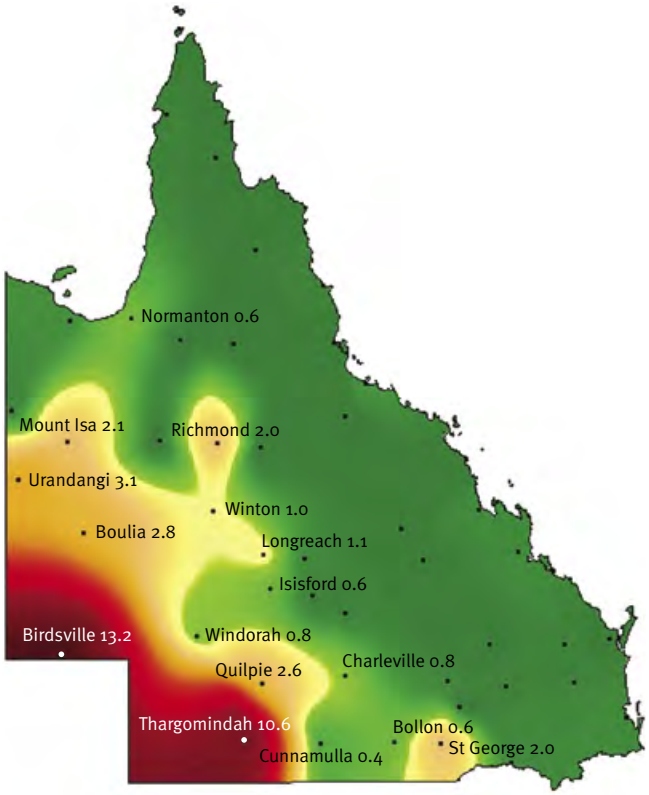


Figure 4.5 *Modelled average DSI, 1992–95*
Source: Griffith University

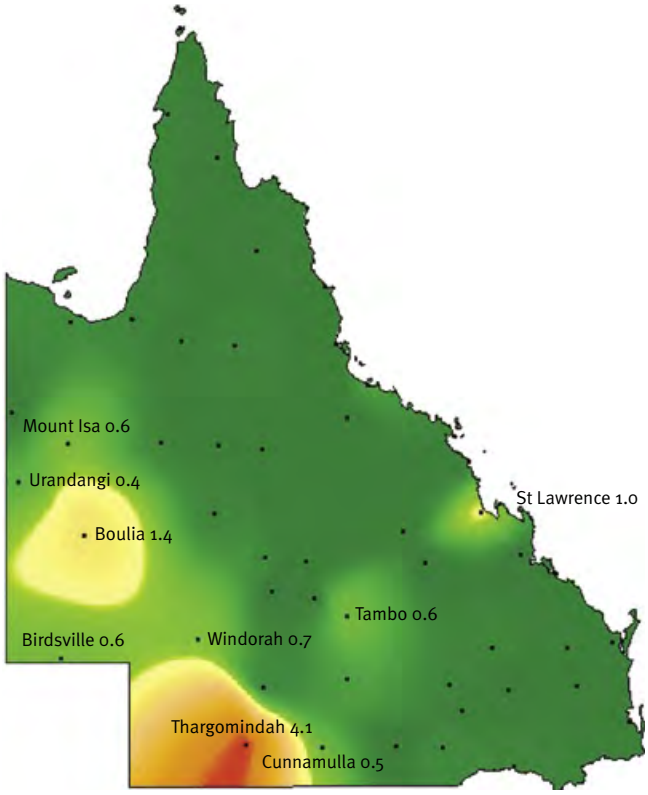


Figure 4.6 *Modelled average DSI, 1998–2001*
Source: Griffith University

Summary of condition and trend indicators

Wind erosion

Period	NRM regions												
	CY	NG	SG	DC	SW	WT	BDT	MK	F	BM	SE	MD	DU
1992–95	▲	▼	▲	▼	▼	N	▼	N	▲	N	N	▼	X
1998–2001	▲	▲	▲	▲	▲	N	▼	N	▼	N	N	▲	X

Key to condition:

- Above-average wind erosion
- Average wind erosion
- Below-average wind erosion
- Not assessed

Key to trend:

- ▼ Deteriorating in relation to long-term (1960–2001) average
- ▲ Improving in relation to long-term (1960-2001) average
- N Wind erosion infrequent in region
- X Not assessed

Mass movement

Summary

Mass movement in Queensland is associated with a combination of vegetation clearance on steep slopes, susceptible rock types and high-intensity rainfall. In some cases, mass movement is amplified after fire events. The areas most susceptible to mass movement are hill slopes, escarpments and the flanks of the Great Dividing Range.

As agricultural, forestry and suburban development continue to extend onto steeper slopes the incidence of mass movement is likely to increase unless appropriate land management planning strategies are applied and best practice engineering design standards are met.

Description

Mass movement is the down-slope movement of earth, rock and soil material, which ranges from imperceptibly slow movements (millimetres per year) to sudden movements or collapses such as rock-falls under the influence of gravity. Landslides vary in size from an individual boulder to millions of cubic metres of material in a debris avalanche. The photograph below shows a typical landslide on grazing land.



Landslide on a steep hill slope near Beechmont, south-east Queensland (Photo: DNRM)

In Queensland, mass movement has not been considered a major form of soil erosion when compared with the erosion caused by wind and water. It tends to be confined to small areas, often on sloping ground, and is perceived to be a problem for only short periods, which can often be remedied by appropriate engineering solutions. Its effects can, however, be destructive, disruptive and, occasionally, fatal. In Australia, mass movement has caused economic losses of about $500 million since 1900. No economic loss figures are available for Queensland.

Queensland's rapidly increasing population creates a demand for more land for many purposes. This places pressure on land that is currently under native vegetation or used for agriculture. Most of the state's population is concentrated on the eastern seaboard in areas that have the highest relief, rainfall and slopes and the highest mass movement potential.

Pressures

Mass movement has not been considered a major hazard to development in Queensland because most events have occurred in rural areas. With increasing population growth and the expansion of suburbs onto steeper, unstable slopes, there has been cause for concern at Commonwealth, state and local government levels.

Human activities and their associated impacts on the environment are one of the main pressures contributing to mass movement. Between 1991 and 2001 Queensland's population increased from 2.96 to 3.63 million people, the highest growth rate experienced by any Australian state or territory. This growth is strongest in south-east Queensland, which absorbs 80% of the new arrivals. Population growth has resulted in an increased demand for land for a variety of urban and rural uses. Consequently, there has been an expansion of native vegetation clearing on sloping ground for agriculture, forestry and suburban development.

Condition and trends

The main areas of Queensland affected by mass movement are in the east on hill slopes, escarpments and the eastern flanks of the Great Dividing Range (figure 4.7). South-east Queensland and Cairns are coming under increasing pressure. No statistics are available on the total area that is potentially susceptible to mass movement.

During 1999–2000, the 12 months before the *Vegetation Management Act 1999* came into force, the average annual clearing rate for many regions increased. In 2000–01, the Act's first year of operation, the tree clearing rate decreased significantly. The effects of accelerated vegetation clearance immediately before the Act's commencement still need to be assessed and documented.



Evidence of mass movement into a watercourse (Photo: EPA)

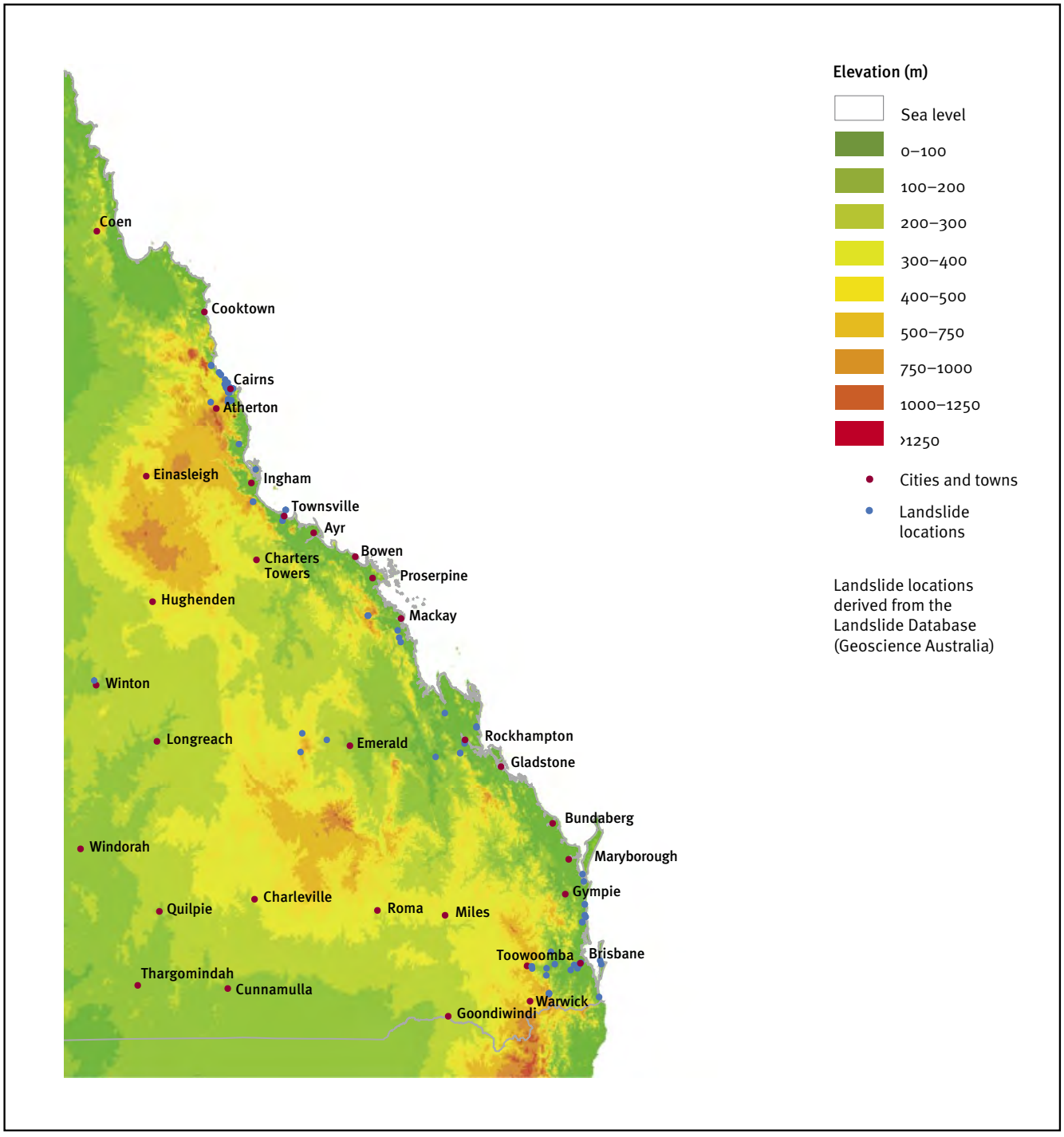


Figure 4.7 *Landslide locations and elevation*

Responses

Responses to the problem of mass movement fall into the following categories: legislation, vegetation management, the use of land development and building codes, and risk management. Legislative responses are undertaken by the 125 local government agencies through *SPP 1/03: Mitigating the Adverse Impacts of Flood, Bushfire and Landslide*; the IP Act; the Vegetation Management Act; and the *Land Act 1994*.

Revegetation of slopes has been undertaken by landholders and community groups with Natural Heritage Trust funds at a number of locations throughout the state.

Before a local government approves a housing development in an area known to be prone to mass movement, it should consider issues including its own planning scheme and policies, Australian Standards, and land development guidelines.

Risk management will help avoid the hazard of mass movement. The potential for loss from mass movement will be reduced through preliminary investigations using risk management principles.

Agricultural soil acidification

Summary

Queensland's highly weathered soils and current systems of agricultural land use make the state vulnerable to accelerated soil acidification. There is a huge discrepancy between the amount of lime currently being applied and the amount required to raise the pH of the state's agricultural soils to a value that will maintain productivity. While this situation persists, subsoil acidification is occurring and the correction of this acidity is a problem. Management strategies can be applied to reduce the rate of acid addition, and should be used, together with a program of regular liming, to counteract the rate of acid addition. A statewide awareness program would assist in dealing with this major land degradation issue.

Description

Accelerated soil acidification occurs when natural ecosystems are disturbed by land development for agriculture. Soil acidification is particularly evident in Queensland soils supporting some horticultural crops, nitrogen-fertilised dairy pastures and sugarcane, and soils under broadacre field cropping over a long period. The major causes of acidification are removal of alkalinity in harvested products, the use of high rates of ammonium-based fertiliser and leaching of soil nitrate. Because of differences in the magnitudes of these factors across cropping systems, rates of acid addition also vary. Often the only recognisable sign of soil acidification is a gradual decline in crop productivity. If acidification is not corrected, the process continues until irreparable damage is done to soil fertility. Then, only crops highly tolerant to acidity can be grown. This limits the options for sustainable production. Subsoil acidity, which is a consequence of inadequate correction of surface soil acidity, reduces crop root growth and restricts crop access to subsoil moisture and nutrients. The major effect of soil acidification is reduced surface cover, which leads to increased runoff and erosion and nitrate pollution of groundwater.

Pressures

The major pressures causing soil acidification are high rates of use of ammonium-based fertilisers, leaching of nitrate below the root zone and high rates of product removal. Management strategies such as reduced nitrogen fertiliser inputs, the use of nitrate-based fertilisers, efficient irrigation practices and the application of lime can be adopted to reduce acidification.

The pressure indicator is the size of the discrepancy between the rate of acid addition inherent in the current agricultural system and the amount of amendment being applied to ameliorate this acid addition. A deficit (amendment application rate less than rate of acid addition) indicates that soil acidification is continuing.

Condition and trends

A Soil Acidification Index (%) has been calculated as the quantity of agricultural lime/dolomite applied to the cropping area of a Statistical Local Area (SLA) as a proportion of the quantity required to neutralise the acidity generated by the current land use (ABS 2002b). Figure 4.8 shows the index for each SLA. It is evident that much of the state's cropping land is not receiving sufficient lime to counteract current acidification, let alone ameliorate any existing acidic soil condition.

The index was sorted according to several broad cropping systems. For the four highest sugar-producing SLAs, the index ranged from 24.2 (Mackay) to 74.5 (Johnstone), indicating a divergence in the adequacy of lime application across the industry. For the four highest hay-producing SLAs, the index ranged from 0.0 (Belyando and Wambo) to 0.7 (Waggamba). Many of the hay-producing soils may be naturally alkaline, but soil acidification will be occurring and soil pH will need to be monitored. The almost complete absence of lime application strongly suggests that there is a lack of awareness among hay producers of the high potential for soil acidification. For the three SLAs supporting the largest banana- and pawpaw-producing areas, the index ranged from 58.0 (Cairns Part B) to 80.4 (Cardwell). This result supports the general observation that many horticultural producers have a regular liming program. However, subsoil acidification is still occurring under these systems because of the very limited capacity of surface-applied lime to neutralise subsoil acidity.



Lime is spread on sugarcane stubble to maintain soil productivity. (Photo: DNRM)

Responses

Surface application of lime is the most common response to soil acidification. There is a large discrepancy, however, between the amount of lime currently being applied and the amount required to raise the soil pH of Queensland's agricultural soils to a value that will maintain productivity. While this situation persists, subsoil acidification is occurring and the correction of this acidity is a problem. One reason for the current lack of liming is the downturn in the economics of the sugar industry, historically one of the biggest users of lime. Lack of awareness of subsoil acidification as a productivity constraint is another reason for less-than-adequate lime applications being made to several horticultural crops. No programs, policies or strategies are currently in place to tackle soil acidification as an issue at the state level.

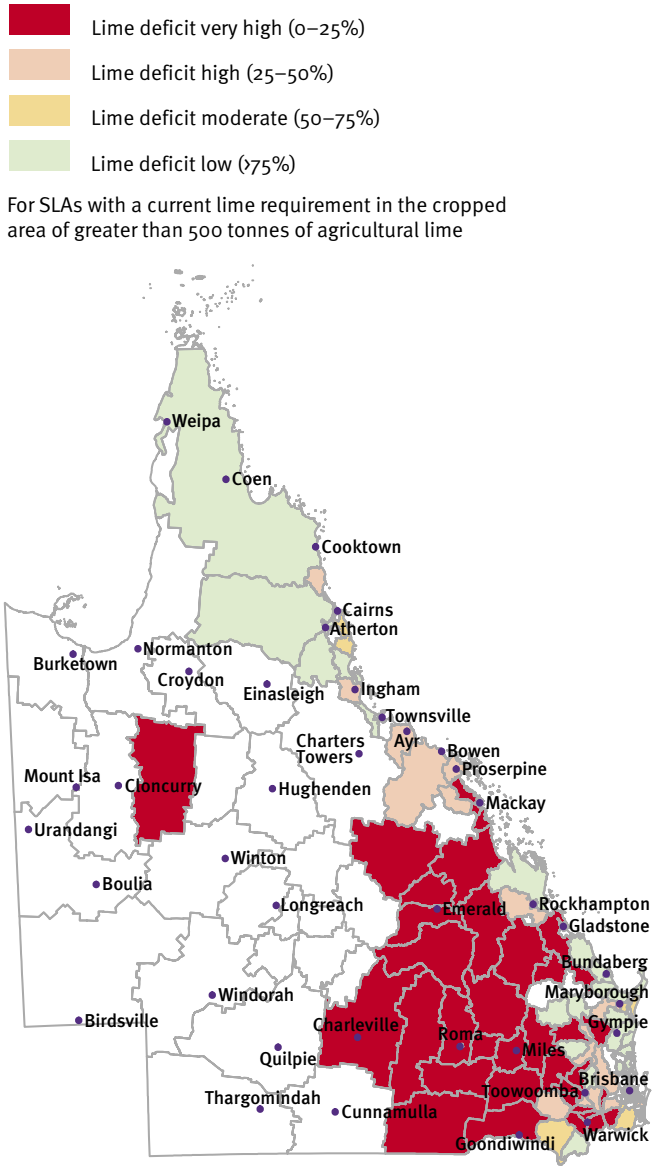


Figure 4.8 *Soil Acidification Index*
Source: DNRM, derived from ABS data

Case study: Reducing acid addition in banana crops

Reducing acid addition rates is an important management strategy for reducing soil acidification. This was demonstrated by improvements in nitrogen (N) fertiliser management in a banana case study (Commonwealth of Australia 2001b, pp. 148–149).

The factors contributing to soil acidification in the banana production system are three acidifying processes:

- nitrate leaching from the applied fertiliser. The current industry practice is to apply an average of 613 kg N/ha/year, predominantly as urea. Nitrate leaching losses in excess of 50 kg N/ha/year have been measured under bananas in the Wet Tropics;
- removal of alkalinity in harvested product. Harvested banana bunches remove an alkalinity equivalent to 200 kg agricultural lime/ha/year; and
- removal of alkalinity from the cropped area in crop residues such as suckers and dead leaves, which are disposed of into the inter-row area.

The net acid addition under these current practices is managed by regular surface applications of agricultural lime at rates of 1–2 tonnes/ha/year.

Identification of the sources of acidification and their magnitude under current practices allowed a 'best management practice' scenario to be developed. This scenario involved:

- reducing N input to 250 kg N/ha/year;
- applying N fertiliser in the form of ammonium nitrate rather than as urea;
- reducing nitrate leaching as a consequence of reduced N fertiliser inputs; and
- returning crop residues to the plant row.

These best management practices can reduce the current acid addition rate by 85%, which greatly decreases the amount of lime required to counteract soil acidification. The industry is moving towards the adoption of these practices as research removes some of the uncertainties associated with current fertiliser and plant residue management.



Soil acidification is particularly evident in Queensland soils supporting some horticultural crops, such as bananas. (Photo: DNRM)

Soil fertility decline and soil carbon

Summary

Soil fertility decline, or nutrient depletion, is regarded as an insidious and serious form of land degradation. In grain cropping lands, nitrogen has declined by 30–45% and despite increasing fertiliser use, improved cultivars and improved crop and land management, grain yields have been stagnant over the past 30 years. Similarly, depletion of phosphorus and potassium is occurring in most areas except those under bananas and sugarcane. In cropping lands soil carbon has declined by 30–60%, with adverse climate impact. Soil fertility restoration measures include sustainable rotations, organic and fertiliser nutrient inputs, and improved soil, plant and animal management. An industry-based awareness program would assist in dealing with this major land degradation issue.

Description

In agricultural systems, significant quantities of nutrients are removed in commercial products, such as grain. In cropping systems, such removal can comprise the major component of soil nutrient removal. Nutrient removal can also occur through removal in hay, silage and grazing; through soil erosion, runoff, leaching and burning of crop residues; and through gaseous losses such as denitrification and volatilisation.



Nutrients taken up by grain crops can be the major component of soil nutrient removal. (Photo: DPI)

Soil fertility is declining in most of the 3 million hectares of cropping lands in Queensland (Dalal and Chan 2001). Nutrient inputs must be sufficient to replace nutrient losses. For example, fertiliser inputs must increase to replace nutrient losses. Inputs of nitrogen can also come from biological nitrogen fixation (nitrogen fixed by legumes).

Pressures

Fertiliser use

As soil fertility declines, nutrient inputs must increase to maintain crop productivity: fertiliser application is one option. Although phosphorus and potassium fertiliser use in Queensland has increased only slightly in the past 30 years, nitrogen fertiliser use rose from 51 000 t in 1970 to 202 000 t in 2000 (Incitec 2002), a rise of 300% over 30 years.

Fertiliser application rates and yield

As fertility has declined and economic pressure to maintain crop yields and quality has increased, the nitrogen fertiliser application rate has risen from 22 kg/ha to 65 kg/ha, an increase of 295%. The area of cropping land, however, only increased from 2.29 million hectares in 1970 to 3.13 million hectares in 2000 (ABS 2001b).

Market prices of fertilisers/products

Fertiliser prices have been increasing since 1970. For example, urea prices increased from $79/t in 1971 to $372/t in 2000. Despite the 470% increase in urea prices during this period, both the total amount and the application rate of nitrogen fertiliser rose, mainly because of economic pressure to maintain yields from cropping lands with decreasing soil fertility.

Condition and trends

Nutrient balance

Significant areas of cultivated lands show a net negative balance (overall net loss of nutrients) of more than 10 kg/ha per annum for nitrogen and phosphorus (Commonwealth of Australia 2001b). Only in small coastal areas, especially on horticultural and sugarcane lands, is nitrogen balance positive, and there it contributes to soil acidification (see 'Agricultural soil acidification', page 4.24) and potentially to nutrient pollution. There are much larger areas of negative potassium balance since potassium fertiliser use is much more limited.

Trends in soil fertility and greenhouse gas emissions

Where fertiliser applications have been limited, trends in soil fertility can be assessed by changes in soil organic carbon (C) concentration in the topsoil, since nitrogen is supplied by mineralisation of organic matter. Figure 4.9 shows the decline in soil organic C on brigalow land cleared in 1935 for cereal grain cropping in southern Queensland. Soil organic C declined by half, from 47 t/ha in 1935 to 23 t/ha in 2000; it was lost mainly as carbon dioxide since the land slope was ‹0.2%, so that erosion losses were minimal. Apart from loss of soil fertility, it contributed the equivalent of 88 t/ha of carbon dioxide to greenhouse gas emissions.

Most of these losses occurred in the first 20 years of cropping. Dalal and Chan (2001) estimated that 3 million hectares of lands cropped for more than 20 years must have emitted an estimated 156 million tonnes of carbon dioxide equivalent. No account was taken of nitrogen losses as nitrous oxide, a potential greenhouse gas with a global warming potential 296 times that of carbon dioxide.

Trends in yield and product quality (wheat protein)

Wheat grain yields fluctuated, primarily in response to seasonal conditions, around the mean yield of about 1.4 t/ha over the past 30 years (ABS 2001b, 2002d). There does not appear to be a trend towards increased yields despite improved crop management practices, including the use of improved cultivars, higher fertiliser application rates and better weed control.

One reason for static wheat yields could be continuing soil fertility decline. Dalal and Probert (1997) estimated that fertility decline was responsible for a potential yield decline of 38% in southern Queensland and 21% in central Queensland, where it is probably partly compensated for by improved crop management practices.

Even in newer cropping areas in central Queensland, wheat grain protein decline is evident in the Central and Southern Highlands (Grainco 2002), where nitrogen fertiliser applications are rarely made.

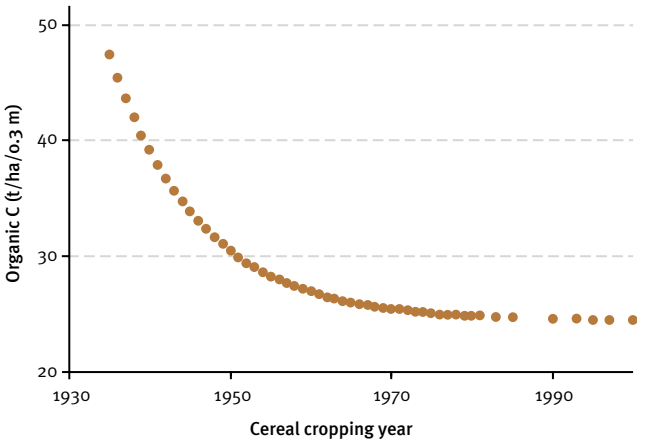


Figure 4.9 *Modelled decline in soil organic carbon since 1935 after land under brigalow was cleared for cereal cropping on the Darling Downs*
Source: Dalal et al. 2003

Area of ley cropping

While nutrient deficiency of phosphorus and potassium can be corrected only by fertiliser and/or manure applications, nitrogen deficiencies can also be corrected with biological nitrogen fixation by crops such as legumes. In Queensland's arable lands, the area under improved pastures increased from 2.5 million hectares in 1970 to 5.7 million hectares by 2000 (ABS 2001b, 2002d), but the trend for legume pastures (ley cropping) in cropping areas is much less clear.

Responses

Trends in fertiliser use

There has been a steady increase of 4000 t/year in nitrogen fertiliser and 500 t/year in potassium use in Queensland over the past 30 years. Trends in phosphorus fertiliser use are less clear, although its use has increased consistently over the past four years.



Ley cropping can correct nitrogen deficiencies. (Photo: L. Knight, EPA)



Wheat (Photo: J. Dunn, DLGP)

Case study: Soil fertility decline and wheat grain yields in the southern Brigalow Belt

Industry scenario

A survey of current practice shows that nitrogen inputs as fertiliser and/or legume nitrogen (pulses, pasture legumes) are slowly increasing as the grains industry faces both static yields and declining wheat protein. An increasing proportion of the total wheat crop now fails to meet the protein criteria for 'Prime Hard' quality classification (Dalal and Probert 1997).

Estimates of fertility decline rates

Based on the results of Dalal and Mayer (1986), fertility trends in the top 10 cm of soil after 20 years of cropping showed that:

- soil organic carbon and nitrogen had declined by 45%;
- organic phosphorus had declined by 38%; and
- total sulfur had declined by 20%.

Practices for reducing soil fertility decline

Identification of the causes of soil fertility decline and their magnitude under current practices allowed a 'best management practice' scenario to be developed. This scenario involved:

- fertiliser application;
- no-till practices;
- pulses/wheat rotation;
- legume pasture/wheat rotation; and
- mixed grass and legume/wheat rotation.

Has best practice worked?

Results from a long-term field experiment at Warra in the southern Brigalow Belt show that, under current tillage practices, wheat yields were similar to the state average of 1.4 t/ha. While no-till practices without nitrogen fertiliser gave similar yields, the application of 75 kg/ha of nitrogen increased yields by 55%. Alternatives to fertiliser use were also effective in increasing yields. For example, wheat yields after chickpea (pulse), medic (legume pasture) and lucerne (legume pasture) increased by 52%, 44% and 68% respectively. Wheat yields after a mixed pasture of legumes and grasses increased by 83%, compared with continuous wheat cropping without nitrogen fertiliser application (Dalal et al. 1998).

Industry implications

While the 'best practices'—no-till practices, fertiliser inputs, pulses in rotation, and ley cropping (legume pasture/cereal cropping)—showed that there are better management options for arresting productivity loss as a consequence of fertility decline, adoption of these practices by the industry is mixed. The less complex management practices such as no-till (and stubble retention), fertiliser applications and pulses in rotation have been adopted rapidly, but the adoption of ley cropping is much more sporadic and slow since it involves mixed cattle and grain enterprises. The industry is moving towards adoption of these practices as research removes some of the uncertainties associated with current best practices.



The effect of soil fertility on cereal production at Warra—degraded land (left) and restored land (right) (Dalal et al. 1995) (Photo: DNRM)

Summary of condition and trend indicators

Soil fertility decline and soil carbon

Indicator	NRM regions				
	F	BM	SE	MD	BDT
Nutrient balance	▼	▼	X	▼	X
Trend in soil fertility	▼	▼	X	▼	X
Trend in yield and product quality	▼	▼	X	▼	X

Key to condition:
Moderate
Poor

Key to trend:
▼ Decreasing
X Not assessed

Soil compaction

Summary

Soil compaction is a problem common to all cropping and grazing lands in Queensland. It is also an episodic problem in both forestry and farmland as a consequence of tree clearing. Like soil erosion, compaction is regarded as a serious environmental problem caused by conventional land management. Yield loss, decreased water and fertiliser efficiencies, unnecessary energy inputs both causing and alleviating the problem, and exacerbated soil erosion all contribute to costs.

Compaction is caused by tillage implements, tyres and animal hoofs, particularly when they traverse moist to wet soil. The outcome is most serious in soils that are initially well structured and therefore of high agrarian value. It is also important for soils that are inherently poorly structured, where compaction exacerbates their hard-setting or crusting nature. Examples span all soils, the cropping, grazing and forestry industries, small- to large-scale enterprises, and all climatic zones.

Compaction is a difficult phenomenon to survey and measure. It is almost always a subsoil phenomenon, so is not immediately visible. Additionally, measurement requires skills and specialised equipment.

Fortunately, soil compaction is reversible. However, land users must first correctly identify soil compaction as a problem before altering components of their management system. Practicable land management systems can be designed to repair compacted soils, and then ensure prevention of future compaction. Although only moderate expertise is required to locate, identify and explain soil compaction, very few land users would initiate such a program. Continued scientific input is required to ensure that the problem is being properly monitored and managed.

There are currently no investigations in Queensland of either soil compaction or ways to ameliorate it. Primary producers and regional groups in agriculture, grazing and forestry continue to require advice on compaction identification, repair and prevention strategies and on associated equipment purchase and use.

Description

Soil compaction is most commonly a subsurface phenomenon, extending from just beneath the soil surface to a depth of 60 cm. Disturbance of the compacted layer by tillage can bring massive blocks of soil to the surface, causing seedbed problems, and further intense cultivation is required to reduce clod size.

The importance of measurement of soil water content is emphasised, as soil compaction considerably reduces both water entry into the soil and crop water availability.

Pressures

The land practices with the greatest potential to cause compaction are excessive tillage, use of heavy machinery, use of conventional tyres and excessive stocking rates. All of these pressures are increased in moist to wet soil conditions.

The greatest potential impact of compaction, in terms of lost productivity, water use and fertiliser use, occurs on the most valuable agricultural land. Expectations in terms of productivity are greatest on better quality land, so the pressure for such land to 'perform and respond' is greatest.

Table 4.9 Soil compaction risk of land use types in Queensland

Indicator	Characteristics of land management system
A—high risk	Strong potential for working of land in moist to wet conditions Intense repeated random traffic or livestock trampling Miminum tillage not adopted No traffic control, retained beds or restricted grazing areas (in wet soil conditions) Rotational cropping rare No awareness programs No or minimal data sets Land use classes:* 3.2, 3.3.3, 3.5, 4.5, 5.2
B—medium risk	Occasional sowing/harvesting in moist to wet conditions Occasional random traffic or livestock grazing Widespread use of reduced till Controlled traffic common Episodic tree clearing Awareness programs common Data collection at key trial sites Land use classes:* 2, 3.1, 3.3.1, 3.3.2, 3.3.4 to 3.3.8, 3.4, 4.1, 4.2, 4.4
C—low risk	Wet harvesting rare Zero or minimum till No random livestock on cropland Controlled traffic throughout Flotation tyres on all heavier equipment (if controlled traffic not possible) Rotation crops intrinsic to system Land use classes:* 4.3, 5.1

*Land use class numbers and definitions after National Land and Water Resources Audit

Source: Commonwealth of Australia 2002b

Condition and trends

Soil compaction is a potential problem in all Queensland's cropping and grazing lands. Table 4.9 defines the practices that can lead to soil compaction. It is also an episodic problem for forestry and farmland as a consequence of tree clearing. It is practically impossible to survey and map the extent of soil compaction due to its subsoil nature. Measurements have been conducted at sporadic, individual (trial) sites, but there are no systematic and documented measurements of condition and trend in any cropping industry. Only a few individual studies exist for the grazing and forestry industries. The clearing of native vegetation is considered to be potentially serious and long lasting in terms of soil compaction but is not documented.

Over the past 10 years the main cropping industries (cotton, grains and sugarcane) have made considerable advances towards resolving soil compaction via a series of on-farm, interrelated land management practices. Maximum benefit is gained from the synergy of the five land practices recognised: routine soil inspection in the field, zero till, controlled traffic, use of flotation tyres, and organic matter enrichment.

The cotton industry led the way in soil compaction recognition, repair and prevention with the introduction, in the mid-1980s, of the 'permanent bed' system, a type of controlled traffic. Rotation/break crops were also introduced to induce natural soil cracking to fracture compacted layers without mechanical ripping.



Soil compaction is a perennial problem in cropping lands. (Photo: EPA)

The grains industry also introduced zero till, controlled traffic and rotation crops from the late 1980s. Controlled traffic has had strong acceptance since the mid-1990s, ensuring that almost all compaction is restricted to permanent wheel tracks.

In the past two years, an increasing number of sugar growers have adopted more sustainable land management practices aimed at reducing costs and controlling compaction. These include changing row spacing and planting density, strategic tillage (cultivating only the rows before a cane crop is planted, leaving the compact inter-rows intact) and use of rotation or break crops, such as soybeans. Flotation tyres are now used on some harvesters and haul-outs to reduce the potential for compaction, particularly during wet harvests. A haul-out is a machine or trailer that runs alongside a cane harvester and receives the cut cane from the field. Once full, the haul-out carts the cane to the nearest rail truck or depot.

Responses

At present, there are no primary producer awareness programs in soil compaction. Measurements of compaction across the cropping, grazing and forestry industries are restricted to one or two trial sites in the eastern Darling Downs, principally measuring soil water content change with various rotation crop programs and controlled traffic.

Controlled traffic, zero (or reduced) till, break crops and flotation tyres are being used increasingly in the grains and sugar industries as repair and prevention methods. The cotton industry already employs these compaction-controlling practices.

Case study: Reducing compaction with zero till

A grains farmer in central Queensland changed from conventional agricultural practices (chisel and disc ploughs for annual land preparation and weed control) to controlled traffic (one small tractor and a spray coupe) with zero till. As a result, his fuel bill dropped from $140 000 a year to $50 000. The farmer's only additional purchase is $20 000 of weedicide a year.





Examples of the changes in farm equipment in the grains industry. Large 4×4 tractors (left) are being used less, replaced by smaller tractors (right) in controlled traffic systems in association with GPS-guided spray coupes on 3-metre axles. (Photos: DNRM)

Summary of condition and trend indicators

Soil compaction

Indicator	Cotton	Grains	Sugar	Horticulture	Dairy	Rangeland	Forestry
Awareness of soil types and their fragility	▲	▲	▲	▲	–	–	–
Previous soil training workshops and soil 'days'	▲	▲	–	▲	–	–	–
Incidence of zero (or reduced) till	▲	▲	▲	–	–	–	
Use of controlled traffic	▲	▲	▲	–	–	–	–
Use of flotation tyres*	–	▲	▲	–	–	–	–
Use of rotation crops	▲	▲	▲	–	–	–	–
Soil compaction	▼	▼	▼	▼	X	X	X
Monitoring of soil compaction	▼	▼	▼	▼	X	X	X
Planned number of soil compaction training workshops	▼	▼	▼	▼	X	X	X

*Flotation tyres may be on only selected equipment, such as the heavier equipment, potentially used in wet soil conditions: harvesters, haul-outs (cane and forestry) and chaser (grain) bins, fertiliser bins etc.

Key to condition:

- Good
- Moderate
- Poor
- Not assessed

Key to trend:

- ▼ Degrading
- ▲ Improving
- X Not assessed
- – No change



Harvesting sugarcane. (Photo: DPI)

Contaminated land

Summary

Contaminated land is largely a historical problem, which often results from poor industrial waste disposal practices. The EP Act provides a framework to identify contaminated land and land that has the potential to be contaminated. Information about such land is recorded on the Environmental Management Register (EMR) or Contaminated Land Register (CLR) and is publicly available. This information enables individuals, the business community and government to make informed land use planning decisions.

Related IP Act provisions ensure that applications for redevelopment of contaminated or potentially contaminated land are referred to the EPA for review. The number of development applications referred to the EPA under the IP Act has increased each year with the growth of urban centres into surrounding industrial areas, particularly in south-east Queensland.

Remediation of sites involves either full clean-up and approved off-site disposal or safe on-site management of contamination under the conditions of a statutory site management plan (SMP). Strategies used are consistent with the *National Environment Protection (Assessment of Site Contamination) Measure 1999* (NEPM) and EPA guidelines.

The EPA and local governments seek to prevent contamination of land by regulating the amount of pollutants released from industrial or other environmentally relevant activities.

Description

The EP Act ensures that information is provided to land purchasers by requiring that property owners advise them if land is listed on either the EMR or the CLR. Over the past five years the EPA has processed an average of 104 230 searches of the registers each year. The searches are often associated with property transactions. The EP Act does not require that land be remediated as a result of listing on the EMR or before sale.

Investigations to have land removed from the EMR are undertaken voluntarily by the landowner/developer or under notice issued by the EPA to abate serious health or environmental risk. Remediation is usually associated with redevelopment proposals. Contaminated land work must be conducted by professionals in accordance with national and state guidelines. A permit must be obtained from the EPA before any contaminated soil is removed from land for treatment or disposal. Remediation works are undertaken to ensure that land will be suitable for the proposed use.

Under the IP Act, the EPA is a referral agency for any development applications involving contamination issues. Development conditions are set by the EPA to ensure that the land is suitable for the intended use. The EPA encourages the use of SMPs, particularly for non-residential uses, to safely manage contamination and minimise development costs. Currently 590 land parcels that are listed on the EMR have approved SMPs.



The oil spill at Lytton, Brisbane, in 2003 required the clean-up of contaminated land and water near the site. (Photo: EPA)

Land listed on the CLR is known to be highly contaminated and poses serious risks to human health and/or the environment in its current condition. The EPA requires that work be undertaken on such land within a specified time to manage these risks.

Pressures

Since 1998 the EPA has reviewed approximately 1530 development applications for contaminated or potentially contaminated land. For approximately 20% of these applications, the EPA has required that some form of contaminated land investigation and/or remediation work be undertaken before approval is issued. The majority of applications referred to the EPA in regard to contaminated land matters over the past five years have involved land in south-east Queensland, mostly within the Brisbane City local government area. Large numbers of applications relate to the increase in development in urban renewal areas of population centres that were former industrial sites.

Condition and trends

Since 1998, 560 sites across Queensland have been removed from the EMR as a result of investigation or remediation works. During this period, 580 permits were issued allowing the disposal of approximately 408 500 m³ of contaminated soil to landfills. Amounts of contaminated soil approved for disposal ranged from 56 554 m³ (between July 1999 and June 2000) to 141 819 m³ (between July 2000 and June 2001). High economic growth in a region typically results in an increase in contaminated sites remediated for redevelopment. This, in turn, results in higher demand for the limited space available at landfill facilities.

Responses

In response to the pressures that urban renewal and the associated clean-up of sites place on limited space at landfill facilities, the EPA requires that contaminated soil be remediated and reused where possible. The EPA also promotes partial remediation of sites and the use of SMPs.



The 'Chemcollect' program helps farmers safely dispose of unwanted chemicals on their property. (Photo: EPA)

The EPA and local governments play important roles in preventing further releases of contaminants to the environment by licensing environmentally relevant activities (ERAs). Licences regulate the quantity and quality of contaminants that can be released to the environment.

The EPA has participated in national programs such as 'Chemcollect' to deal with the disposal of unwanted farm chemicals. The EPA and Queensland Health have also played a prominent role in the development of the NEPM to seek national consistency in the assessment of site contamination.

The EPA is leading research into the assessment of contaminated land associated with the mining industry and the implications for post-mining land uses such as low-intensity grazing, environmental effects of mining contaminants and health effects from ingestion of contaminated soil by livestock.

Case study: Queensland Cement Limited

The Darra Works site of Queensland Cement Limited (QCL) began closure in 1997, after approximately 80 years of operation. The QCL land was contaminated with waste cement kiln dust (CKD), hydrocarbon and heavy metal wastes, and buried drums of various chemicals and greases, and was on a large landfill area containing various potentially hazardous wastes.

The site was systematically investigated for contamination. Strategies were developed to maximise the site's development potential and safely manage site contamination. Industrial, commercial and residential land uses were identified and remediation strategies were developed. Complete remediation was undertaken for proposed residential uses and SMPs were used, where effective and economic, in proposed industrial areas.

The area is now occupied, with carefully planned and separated industrial and residential precincts. Approximately 1 000 000 m³ of waste CKD with residual cementing properties was removed from the site for storage and reuse as a waste treatment material, for building foundations, and for potential use in treating acid sulfate soil.

To improve workload management and customer service, the EPA introduced a voluntary initiative in August 2000 to have site assessment and remediation work independently assessed under a professional third party review system. This system ensures that work is of a high standard and streamlines administrative decision making processes.



Clean-up and removal of waste from a contaminated site (Photo: EPA)

Pasture condition

Summary

Pasture condition is likely to decline in the near future due to a combination of drought in 2002 and an increase in the density of trees, shrubs and noxious weeds. This overall trend reverses those in many regions in the late 1990s and is more common in northern Queensland.

More resources are needed to run a long-term monitoring program against which progress towards goals can be consistently measured. Early warnings of impending below-average rainfall did not result in as many animals being turned off early as was anticipated. Educational packages being developed champion a better balance between sustainable grazing land management and high-value animal production.

Description

Pasture condition is a measure of the medium-term stability and forage production potential of the pasture within a grazing management unit, usually a single paddock. The criteria measured may vary according to the nature of the pasture. In the QGraze system, measurements are made of groundcover, the frequency of perennial palatable grasses and the degree of surface soil degradation. Current forage bulk and greenness are not good measures of pasture condition, but are useful for predicting short-term animal performance.

Density of overstorey trees and shrubs is not always used when assessing pasture condition, but is always incorporated into measures of landscape health. Pasture condition may be relatively poor if unpalatable perennial plants are dominant, yet the land may be environmentally stable with minimal runoff and erosion, no human health risks and no serious change in soil structure.

Under Queensland's climate, groundcover above 30–40% is considered satisfactory for minimising runoff and erosion on low (‹3%) slopes, but on steep slopes in high-rainfall areas at least 70% cover is needed. A high proportion (usually ›70%) of perennial, palatable productive grasses is very important for good animal production and pasture drought tolerance.

Pasture condition is often rated in five classes (excellent, good, fair, poor and very poor), but these may be reduced to three (good, fair and poor). Any pasture rated fair or above will respond well to prudent grazing management. Pastures in very poor condition will require significant inputs of money and machinery to restore them to fair condition. The photographs below show typical examples of poor and good pasture condition.

Pressures

The major pressure on pasture condition is grazing animal biomass. Less significant but still important are invasive plants, drought, wildfires and tree thickening. The greatest potential for change exists where one or more of the minor factors interacts with grazing pressure. Such changes may be beneficial or degrading, depending on the grazing management system used.

International commodity prices exhibit large cyclical changes, and when they are low graziers are under economic pressure to temporarily increase stocking rates. If that extra grazing pressure becomes entrenched, pasture condition declines. Prolonged supplementary feeding during drought will usually produce that undesirable outcome. In tropical woodlands, high stocking rates usually reduce the chances of wildfires or controlled burns and hasten the natural tendency for trees and shrubs to thicken.

It can be difficult to get widespread agreement on which plants are undesirable. The same plant, for example black speargrass, can be desirable in one region and undesirable in another. Pasture weeds are a serious problem, but the best pasture plants can be regarded as environmental weeds in some conservation areas. A balanced, constructive approach to their use and management is appropriate.

Excessive kangaroo numbers can cause difficulties in the southern half of the state, especially when producers are attempting to spell pastures.

Condition and trends

Where QGraze and similar assessment methods are used, a reasonable proportion of Queensland pastures are in fair to good condition. Total dominance by buffel grass (*Cenchrus ciliaris*) or shrubby stylo (*Stylosanthes scabra*) may present difficulties in some regions in the future. Mulga and *Aristida*/*Bothriochloa* pastures are probably the worst for decline in condition.

Condition trends were generally upward after the early 1990s, but the current widespread drought may trigger a downward trend until a run of good growing seasons occurs. Downward trends seem more common in the northern half of the state. Weedy exotic grasses such as giant rat's-tail pose challenges in higher-rainfall regions.





Poor pasture condition (left) can occur as a result of heavy grazing pressure, and good pasture condition (above) can be achieved with strategic grazing management. (Photos: DPI)



Giant rat's-tail is a weedy exotic grass found in higher rainfall regions of Queensland. (Photo: EPA)

Soil structure and fertility decline are not widespread problems on grazing lands. Pressure points exist along riparian zones, around watering points and in holding paddocks.

Statewide assessment in November 2002 found that many regions had much better groundcover than expected. Hence, protection against intense storms is often adequate and the potential to recover after the current drought is still good. The threat of degradation seems greatest where spring fires burnt in 2001 in the north-west; in the Burnett, where weedy grasses are now endemic; where mulga feeding is maintaining stock numbers for too long; and on river floodplains upstream of the Channel Country.

Responses

The pastoral industries recognise the need to enhance grazing land management and have recently developed two important educational packages. One is a ruminant nutrition package for north Australian cattle and the other is a grazing land management package. Both have core information augmented by specific local information and ideas. Two other commercial products available emphasise 'crash grazing', a practice that involves grazing large numbers of stock over a short period.

The trend is towards a greater understanding of and ability to identify key native plants and a greater willingness to strategically manage grazing pressure on pastures. Regional plant identification guides have helped greatly.

The response to the widely publicised predictions of much below-average 2002 winter and 2002–03 summer rainfall was less than expected in some regions: more animals than expected have been retained and handfed.

Summary of condition and trend indicators

Pasture condition

Indicator	NRM regions												
	CY	NG	SG	DC	SW	WT	MK	F	BM	SE	MD	DU	BDT
Desirable condition	▼ f	▼ f	▼	–	▼ r	–	▼	▼	▼ w	▲	▲	▼	–
High use	–	▼	–	–	▼ m	–	?	▼	–	–	–	▼	–
Undesirable invaders	▼ r	▼ r	▼ p	–	–	?	–	–	▼	–	▼	–	▼ w
Extension activity	–	–	–	–	–	▼	–	▼	–	–	▲	▲	▲

Key to codes: f = fire frequency; m = mulga feeding; p = prickly acacia; r = woody regrowth; w = weeds.

Key to condition:
- Good
- Moderate
- Poor
- Not assessed

Key to trend:
- ▼ Degrading
- ▲ Improving
- ? Not clear
- – No change

Weeds and pests

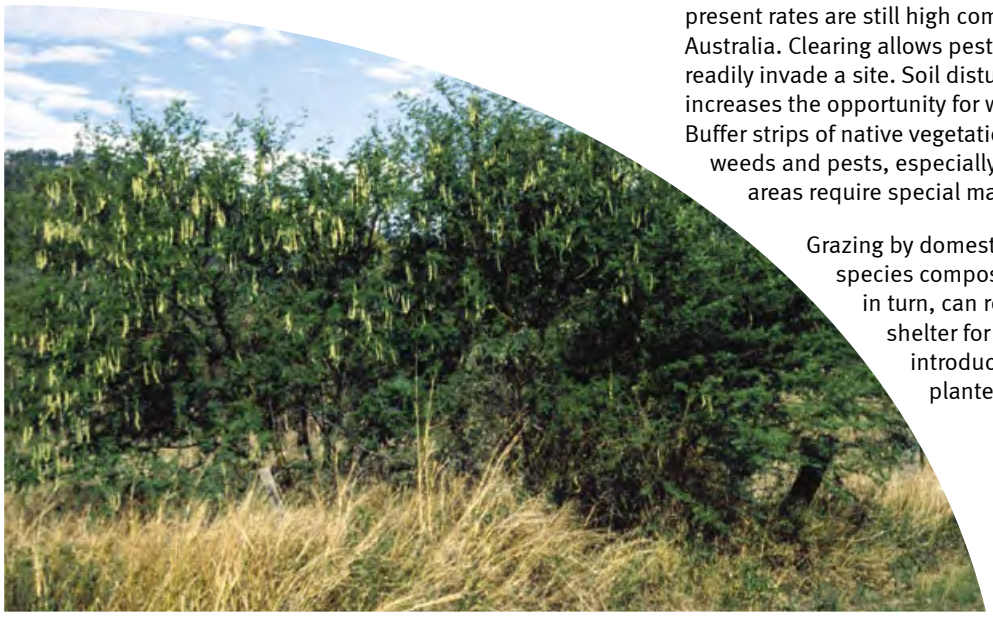
Summary

Development of the National Weed Strategy in 1999 increased the recognition of weeds as an important issue for Australia. Specific funding for weed management has been made available. Queensland developed a state Weeds Strategy consistent with the national strategy. The Queensland Government and local governments continue to provide funding for prevention, detection, eradication, research and management of pest plants and animals. The Queensland Pest Animal Strategy was recently developed.

Several serious weeds, including mile-a-minute (*Mikania*), miconia, limnocharis, giant sensitive tree (*Mimosa pigra*) and Koster's curse (*Clidemia*), and pest animals (notably fire ants) were discovered recently in Queensland. Most are limited in extent. Eradication campaigns (notably for fire ants) are in place. Biological control is having a major impact on several serious pests, including rubber vine (*Cryptostegia grandiflora*), parthenium (*Parthenium hysterophorus*) and rabbits (*Oryctolagus cuniculus*). Further research, especially with fungal pathogens, is a priority for weeds and locusts. It is important that the state maintain scientific and operational readiness to undertake containment or eradication of newly discovered pests.

Description

Pests are plants and animals that use specific resources that could otherwise be used for agricultural production. For example, prickly acacia (*Acacia nilotica*) reduces grass production in Mitchell grass downs, and feral goats (*Capra hircus*) eat vegetation that could otherwise be used by sheep. Pests also have important indirect environmental impacts on agricultural production. Rabbits eat vegetation closer to the ground than domestic livestock, leading to reduced groundcover and increased erosion (short-term impact), in turn leading to the death of native plants within pastures and the displacement of native animals (long-term impact). Pest animals can harbour diseases of livestock; for example, feral pigs (*Sus scrofa*) would be a major carrier of foot-and-mouth disease should that ever enter Australia.



Prickly acacia reduces grass production in Mitchell grass downs. (Photo: EPA)

Weeds, pests and diseases can have an indirect effect: they can lead to restrictions on sales of produce and services (either within Australia or for export). Management costs aside from direct control are also increased: for example, livestock must be kept in holding paddocks so that all prickly acacia seed has moved through the animals' gut systems before they are moved to areas that are free of prickly acacia. Weeds and animal pests cause major environmental damage (see Chapter 7, 'Biodiversity').



Pests such as feral pigs can harbour diseases of livestock. (Photo: DNRM)

Pressures

International travel and trade are increasing, bringing greater opportunities for accidental pest introductions. The keeping of exotic plants and animals is popular and some people try to circumvent importation laws. It is also easy to order seeds through Internet sites and some of these imports escape detection.

The public's general desire for reduced use of chemicals increases the attractiveness of biological control. Plant pathogens are becoming recognised as an under-used source of biological control agents.

Tree clearing within Queensland is decreasing, although present rates are still high compared with other parts of Australia. Clearing allows pest plants and animals to more readily invade a site. Soil disturbance due to clearing increases the opportunity for weeds to become established. Buffer strips of native vegetation are prone to invasion by weeds and pests, especially in riparian areas. These areas require special management.

Grazing by domestic livestock can alter plant species composition in grazing lands, which, in turn, can reduce availability of food and shelter for birds and other animals. Some introduced pasture species spread from planted areas and can become weeds.

Condition and trends

Introductions of plants and animals (mainly invertebrates) continue. Fortunately, relatively few actually become established or naturalised, and only a small percentage become serious pests. However, some of these pests—for example, red-imported fire ants (*Solenopsis invicta*) and Siam weed (*Chromolaena odorata*)—are very serious and eradication is under way.

Biological control agents are having considerable impact on some widespread pests. In particular, rubber vine, parthenium and rabbits are being reduced in distribution and vigour.

Recently discovered plants that are under control include mile-a-minute, miconia, limnocharis, giant sensitive tree and Koster's curse. Reductions in some restricted plants, such as Siam weed and honey locust (*Gleditsia triacanthos*), have been achieved by active campaigns. Reductions in some widespread plants (prickly acacia and rubber vine) have been made by using strategic control approaches.

Responses

The National Weed Strategy was finalised in 1999. Within this framework, the Queensland Weeds Strategy has been developed. A number of strategies for individual pests are in place or are being developed. There are containment lines for rubber vine and prickly acacia, which provide a framework for strategic control operations. Local governments are working together in regional groups to maximise the effectiveness of their control work.

The Strategic Weed Eradication and Education Program (SWEEP) continues to target weed infestations of strategic importance. Management strategies are being developed and/or improved for many weeds within the state.

Coordinated campaigns against wild dogs are commonly undertaken. An effort to control rabbits on the Bulloo River in south-west Queensland is targeting one of the largest infested areas. Control of locusts relies on early intervention to reduce the build-up of several generations during the one year.

Biological control agents are being sought for weedy *Sporobolus* spp., bellyache bush (*Jatropha gossypifolia*), cat's claw creeper (*Macfadyena unguis-cati*) and mother-of-millions (*Bryophyllum* spp.). Development work continues on some agents already released on lantana (*Lantana camara*), parthenium, Siam weed, prickly acacia and groundsel bush (*Baccharis halimifolia*).

National Competency Standards for Vertebrate Pest and Weed Management have been established following national consultation with state and interstate agencies, private contractors and local governments. The Australian National Training Authority (ANTA) approved the standards in May 2002. Formal courses in conservation and land management will be delivered through selected state agricultural colleges. These will provide those involved in pest management with opportunities for training and recognition of skills.

The Land Protection (Pest and Stock Route Management) Act was passed in 2002. This legislation provides for pest plants and animals to be declared in three classes, each of which imposes a different set of obligations on landholders. It recognises environmental pests for the first time. Each local government will be obliged to develop pest management plans for the area it controls.



Development of biological control agents for lantana is continuing. (Photo: EPA)



The Land Protection Act obliges local governments to prepare pest management plans. (Photo: DNRM)

Case study: Fire Ant Control Program



Red imported fire ants (Photo: DPI)

Red imported fire ants (*Solenopsis invicta*) were found in Brisbane on 22 February 2001. The Department of Primary Industries declared fire ants a pest under the *Plant Protection Act 1989*. The Queensland Government began to survey the extent of the infestation and investigate ways of eradicating the pest. The red imported fire ant is now a notifiable pest under the Plant Protection Act. This means that landholders who think or know that they have fire ants on their property are legally obliged to inform DPI.

In June 2001, three entomologists from the USA (Professor Bart Drees, Dr Charles Barr and Dr Sanford Porter) visited Queensland to examine the problem. By September 2001, a Fire Ant Control Centre had been established and a $123 million nationally funded eradication program started.

By October 2001, the first on-ground control works in the eradication campaign had begun. In March 2002, regulations were introduced to restrict the movement of material that posed a high risk of spreading fire ants. Businesses selling or moving high-risk material, such as soil, pot plants, turf, hay and mulch, were encouraged to develop an approved risk management plan. Without such a plan, businesses must complete a Fire Ant Declaration before moving high-risk materials.

Eradication of fire ants from the south-east corner of Queensland is proceeding well; around 90% of nests discovered so far were dead after the first four of 12 treatments. The success of the fight against the fire ant's establishment depends on all members of the community continuing to check their land and report potential infestations. The second year of treatments began in spring 2002.



Tagging fire ant nests for research (Photo: DPI)

Summary of condition and trend indicators

Weeds and pests

Indicator	NRM regions												
	CY	NG	SG	DC	SW	WT	MK	F	BM	SE	MD	DU	BDT
Number, density and distribution of pest plants	▲ rv	▲ rv	▲ rv	▲ pa, mesq, park	–	▼ new	–	–	–	▼ urb	–	–	–
Number and distribution of established feral animals	–	–	–	▲ rab	▲ rab	–	–	–	–	▼ deer	▲ rab	–	–
Number of introduced and naturalised plant species	–	–	–	–	–	▼ grdn	▼ grdn	–	–	▼ grdn	–	–	–
Number of introduced animal species	–	–	–	–	–	▼ ca	–	–	–	▼ fa	–	–	–
Local government pest plans	▲ (not appropriate to report by region; more populous shires generally are better placed to develop such plans)												
Number of biological control agents released	▲ (not appropriate to report by region; few weeds are confined to individual regions)												

Key to codes: rv = rubber vine; pa = prickly acacia; mesq = mesquite; park = parkinsonia; new = new introductions; urb = urban areas; rab = rabbits; deer = deer; grdn = garden plants; ca = crazy ants; fa = red imported fire ants

Key to condition:
Good
Moderate
Poor

Key to trend:
▼ Degrading
▲ Improving
– No change

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Waterfall, Toolona Creek, Lamington National Park (Photo: EPA)

5 Inland waters

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Authors

Brian Bycroft, Diane Conrick, Robert Dick, Tony Horton, Vivienne McNeil, Glen Moller, Stuart Wade and Natasha Witting, Department of Natural Resources and Mines; Dr Peter Jackson, Department of Primary Industries; Bill MacFarlane, Environmental Protection Agency

Reviewer

Colin Creighton, former CEO of National Land and Water Resources Audit

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Introduction

Queensland, like other Australian states and like countries overseas, faces mounting evidence that many of its water use practices may be unsustainable in the future (DPC 2002). Fresh water is one of nature's most precious resources and, while it is renewable, appropriate care must be taken to ensure that its rate of use does not exceed the rate at which it can be replenished. It is vitally important that the quality of water remain suitable for its intended use, whether this is for drinking, agricultural or industrial use, recreation and aesthetics, or ecosystem protection.



Water may be used for many purposes including recreation, drinking, irrigation or agricultural use. The quality of the water needs to be suitable for its intended use. (Photo: DNRM)

Diversion and extraction of water affect both the quantity and quality of the water resources available to other users, including the environment. Loss of deep-rooted vegetation causes erosion problems, as well as salt deposition from a rising watertable. Contamination of waterways by pollutants, including agricultural chemicals, mining tailings and industrial and urban wastes, threatens water quality.

This discussion of inland waters deals with groundwater, surface waters and aquatic ecosystem health. Key environmental issues involving groundwater relate to the levels of subartesian water, maintaining pressure in artesian bores and groundwater quality. Key issues for surface water include water quantity and quality. For the purpose of this report aquatic ecosystem issues encompass habitat, wetlands and fish. The pressures, conditions and trends and responses relating to these issues are discussed. Ideally, many of the individual measures should be aggregated to give an overall picture of the condition of inland waters, but at this stage, because of the inadequacy of the data, this is not possible. Data in this chapter are presented by Natural Resource Management regions where possible.

The major pressures on Queensland's inland waters were documented in *State of the Environment Queensland 1999* (EPA 1999a) and these pressures are essentially unchanged. However, since 1999 a number of significant programs have been implemented for the protection, enhancement or restoration of Queensland's inland waters to counter the pressures. An important initiative has been the implementation of basin-wide water resource plans (WRPs) to underpin ecologically sustainable water resource management. WRPs apply to a catchment's rivers, lakes, storages, springs and, where necessary, groundwater and overland flow. These plans provide a framework within which future water allocations and development can be reviewed to ensure that they are within a plan's water security and ecological objectives. These objectives balance the catchment community's social, economic and environmental needs.

The Great Artesian Basin Sustainability Initiative (GABSI) has been developed to improve groundwater management through bore rehabilitation and channel piping programs. Water entitlement and environmental flow assessment and provision have been implemented under the 1994 Council of Australian Governments (COAG) water reform agenda as well as river and catchment vegetation/water assessments under the National Land and Water Resources Audit (NLWRA). Support from the Natural Heritage Trust (NHT) and other funding projects across the state, in conjunction with other complementary initiatives such as vegetation management planning, is contributing to improving the health of river systems. With irrigation being the largest water use sector in the state, Rural Water Use Efficiency Initiatives (RWUEIs) have been developed and adopted by several agricultural industries. Wetland retention programs have been implemented under the Strategy for the Conservation and Management of Queensland's Wetlands (SCMQW) and wetland protection has been implemented under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). The National Action Plan for Salinity and Water Quality (NAPSWQ) is a recent initiative that has state and Commonwealth backing. Its impact will not be apparent for some time.



Irrigation is the largest water use sector in Queensland. (Photo: DNRM)

In order to sufficiently protect Queensland's inland waters it is vital to have ready access to good-quality information. While many of the environmental indicators mentioned in this chapter are monitored, quite often they are not monitored over long periods, or are monitored within limited spatial areas, or the information is available only for supplemented systems. Information deficiencies, specifically those related to overall water use, remain a concern. Under the state's water resource planning and monitoring framework, however, improvements are being made to the quality of available information on inland waters.

Groundwater—subartesian water levels

Summary

Drought conditions typically result in increased abstraction to produce an overall decline in groundwater level. This trend has been observed recently in Queensland as a result of a ten-year period of predominantly below-average rainfall (NLWRA 2001). In areas of regionally low-level abstraction, groundwater levels have remained relatively static, particularly along the far north Queensland coast. An exception to the general decline can be observed in the Condamine River Basin, where surface water infrastructure in the Upper Condamine River system has resulted in more frequent flows downstream and increased aquifer recharge. Future requirements for groundwater use are currently being assessed in the major use areas through the formulation of water resource plans (WRPs).



Groundwater from bores can be pumped into channels to supply water for stock. (Photo: DNRM)

Description

Demand for groundwater in Queensland is primarily for urban use, domestic purposes, stock watering, irrigation and some industrial use. Fluctuations in groundwater level tend to occur in response to rainfall events, the magnitude of the fluctuations being influenced by the amount of local abstraction.

Queensland's groundwater resources are contained within three basic aquifer types: porous sedimentary rocks, unconsolidated sediments and fractured rocks. Bore yields in the entire range of aquifer types throughout the state vary from as little as 0.5 litres/second (L/s) to more than 100 L/s.

The state has been divided into groundwater management units (GMUs), a term that describes the productive aquifers, and unincorporated areas (UAs), a term that describes the remainder of the state (NLWRA 2001).

The annual sustainable yield of the groundwater resource in Queensland has been estimated to be approximately 2.5 million megalitres (ML) (NLWRA 2001). Actual use of the resource is limited, however, to approximately 1.8 million ML annually. This is due in large part to protection of national parks, state forest and World Heritage Areas as well as the low demand on available groundwater in coastal regions where the tropical climate provides high annual rainfall (NLWRA 2001).



Groundwater resources in national parks, state forests and World Heritage Areas are protected and not available for use. (Photo: DNRM)

Pressures

Subartesian water extraction rates

Experience indicates that demand for groundwater in Queensland from urban users and for stock and domestic purposes, agricultural, irrigation and industrial use will continue to increase. Figure 5.1 shows the levels of abstraction in different parts of the state. Unmanaged growth will place considerable strain on existing infrastructure and available water resources. Where applicable, water demand was projected for the years 2020 and 2050 in each GMU. Based on the collective projections for all GMUs in the state, it is expected that groundwater use will be between 1.8 million and 2.0 million ML/year in 2020 and 2050 (NLWRA 2001). Future requirements are currently being assessed in the major use areas through the formulation of WRPs.

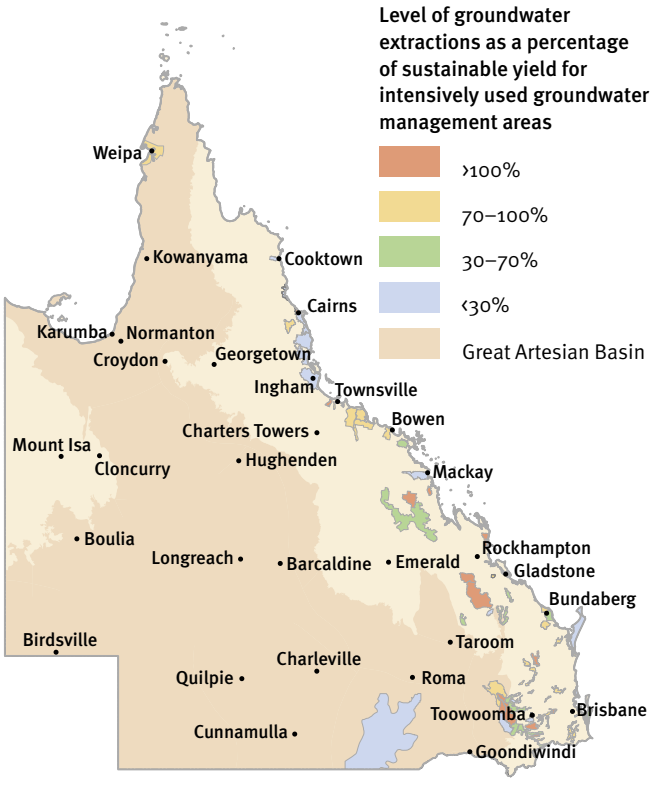


Figure 5.1 *Levels of subartesian groundwater abstraction*
Source: NLWRA 2001

Condition and trends

Groundwater levels

Groundwater levels throughout the state are measured periodically by a network of selected monitoring bores. Bore hydrographs were compared with rainfall trends and the majority of the comparisons revealed that groundwater level fluctuations tend to occur in response to rainfall events. The magnitude of the fluctuations was influenced by the amount of local abstraction. Typically, drought conditions resulted in increased abstraction to produce an overall groundwater level decline. These trends were typical of most GMUs.

Recently the major trend in groundwater levels across Queensland has been a groundwater level decline. This correlates with more than half the GMUs being over-abstracted or approaching the upper limits of sustainable extraction and a ten-year period of predominantly below-average rainfall. In areas of low-level extraction, groundwater levels have remained relatively static, particularly along the far north Queensland coast.

Exceptions to the general decline can be noted in a number of GMUs in the Condamine River Basin, where surface water infrastructure in the upper reaches has resulted in more frequent flows downstream and increased aquifer recharge.

Responses

Water management

WRPs being produced under the *Water Act 2000* will assess and allocate water resources in consultation with the local community and industry. These planning processes will take groundwater issues into account. Other management initiatives include the Rural Water Use Efficiency Initiative (RWUEI), which aims to achieve best practice in irrigation water management, and demand management, which aims to minimise waste and reduce consumer demand. This, in turn, will relieve strain on existing resources and can defer the need for capital investment, reduce operating costs, minimise environmental impacts on natural systems and provide additional water for new users.

Summary of condition and trend indicators

Groundwater—subartesian water levels

Groundwater management unit	Indicator
	Aquifer condition
Lockyer Valley	▼
Condamine Alluvial System	▼
Darling Downs Basalts	▼
Atherton Basalts	–
Burdekin Delta	▼
Burdekin Irrigation Area	▼
Bowen	▼
Pioneer Valley—Bakers Creek	▼
Pioneer Valley—Marian	▼
Callide Valley	▼
Dee River	▼
Bundaberg Irrigation Area—Gooburrum	▼
Bundaberg Irrigation Area—Woongarra	▼
North Stradbroke Island	▼

Key to condition:

Good	aquifer storage capacity greater than average, with levels stable or improving
Moderate	aquifer storage capacity greater than average, with levels declining
Poor	aquifer storage capacity lower than average, with levels declining
Not Assessed	

Key to trend:

– Stable
▼ Declining

Case study: Groundwater management in the Condamine

The Condamine Catchment Management Association (CCMA) has developed a project for groundwater systems management planning for sustainable production in the Upper Condamine catchment (CCMA 2002). The Condamine Alluvial System, which comprises several GMUs, has been identified as a system being exploited as a result of competing demands for resource use. The CCMA project will develop and implement integrated resource management strategies that take into account the full range of environmental, economic, land and social influences. It aims to promote better awareness, acceptance and adoption of sustainable and balanced use of groundwater resources by community groups and individuals, as well as increased community awareness of and involvement in water resource management.

Comprehensive inventories of the level of development, available resources and performance of the major groundwater systems will be assessed in the initial phase of the project. From these, appropriate management strategies will be developed. Information will be collected on an individual aquifer/catchment basis and will include:

- aquifer extent and dimensions;
- number and type of existing groundwater facilities;
- estimate of annual extractions;
- assessment of existing water level monitoring data to establish water level trends and system performance;
- assessment of water quality data to establish water quality ranges and variations throughout the system; and
- identification of any quality changes and trends.

The second phase of the project will produce groundwater status reports and information bulletins that will be disseminated to all groundwater user groups, as well as being suitable for community awareness and education (CCMA 2002).

Groundwater—artesian bore pressure

Summary

Uncontrolled bores and excessive water extraction from the Great Artesian Basin (GAB) have reduced basin pressures by over 80 m in some locations. Rehabilitation of bores under the Great Artesian Basin Rehabilitation Program started in 1989 and resulted in 347 bores being rehabilitated and 2078 km of bore drains being replaced with piping. Since 1999, another 69 bores have been rehabilitated under the Great Artesian Basin Sustainability Initiative (GABSI) and a further 1747 km of bore drains have been replaced. The works undertaken between 1989 and 2002 have resulted in water savings of over 80 000 ML/year. The rate of pressure decline has fallen in many parts of the basin and a long-term pressure recovery of 5 m is expected.



Water losses from damaged bores and bore drains are very high. (Photo: DNRM)

Description

The GAB is one of the world's largest sources of artesian water. It is the most extensive groundwater resource in Queensland and is often the only source of water in remote areas. Water pressure is a key attribute of an artesian water resource, which provides a relatively low-cost water supply. Wasteful water flows through uncontrolled discharge from artesian bores are resulting in the continuing decline in artesian pressures in parts of the GAB. As a result, an increasing number of water users are losing access to artesian water. Reduced natural discharge in response to declining artesian pressure is also having a detrimental impact on groundwater-dependent ecosystems (see 'Aquatic ecosystems—wetlands', page 5.27) and associated biodiversity values. Uncontrolled discharge to bore drains is causing environmental degradation by contributing to the spread of feral animals and weeds, as well as wasting water that could otherwise be used for production or to maintain pressure in the aquifer.

Due to their spatial extent, the state's groundwater resources have been divided into management zones, which are referred to as groundwater management units (GMUs).

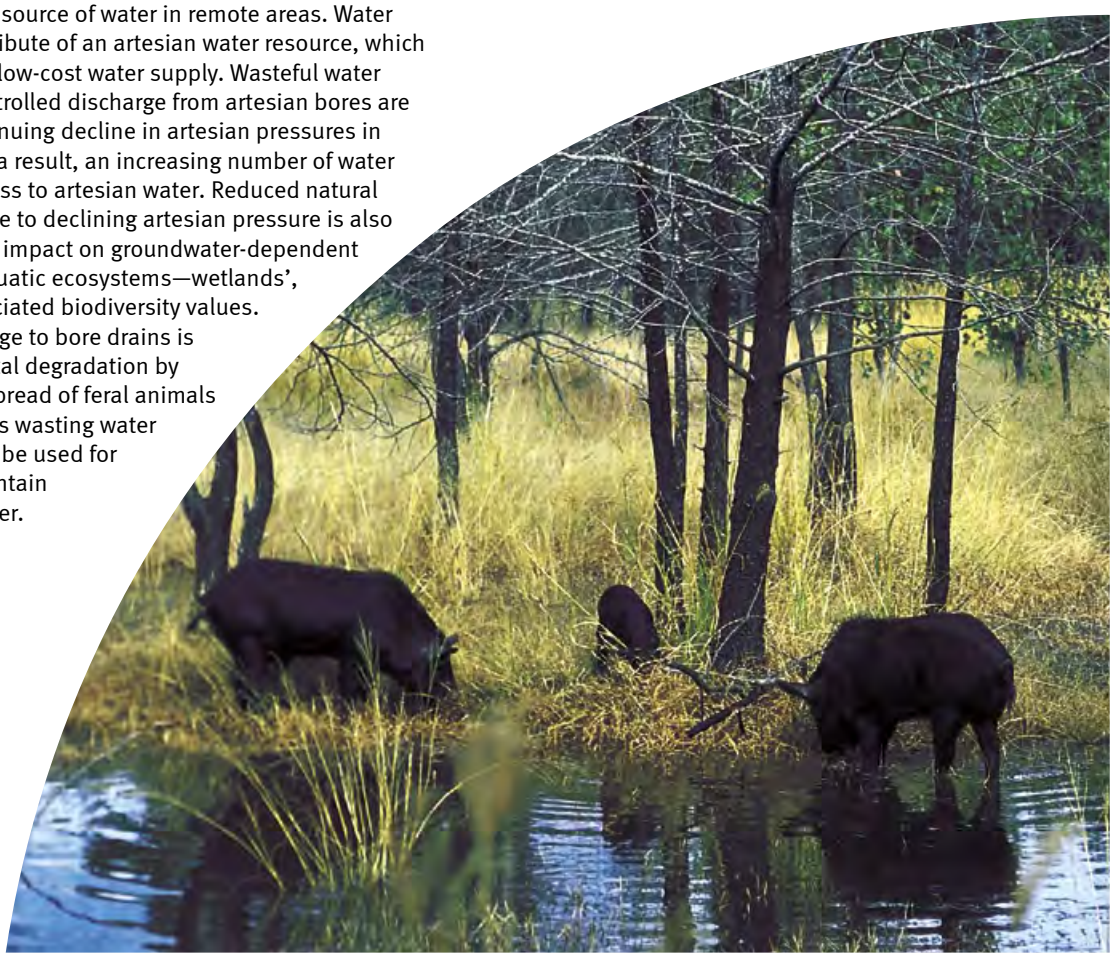
Pressures

Number of open artesian bores

In July 2002, Queensland had 567 open artesian bores and the length of bore drains was 15 305 km. Waste of water from the bores and bore drains remains a major problem. Only 5% of the water flowing into bore drains is consumed; leakage and evaporation account for the loss of 95%. This waste results in not only declining aquifer pressure but also significant environmental degradation through the spread of weeds such as prickly acacia and the provision of habitat for feral pigs and other agricultural pests.

Rate of recharge of GAB aquifers

Recharge of the GAB aquifers results from direct infiltration of rainfall and watercourses into the outcropping sandstone aquifers and leakage through unconsolidated sediments overlying the aquifers. Recharge water moves very slowly through the basin at one to five metres a year, in a generally southward direction; therefore, the rate of replenishment is very low. In large groundwater systems such as the GAB, water extracted today could have entered the aquifer many thousands of years ago. Studies have found that water near the centre of the GAB infiltrated the basin more than a million years ago (GABCC 1998).



Leaking bore drains can provide habitat for pests such as feral pigs, which cause environmental degradation and use resources such as grazing lands. (Photo: DNRM)

Condition and trends

Trend in artesian bore water pressure

In 1914 total flow from bores in the GAB peaked at 750 000 ML a year. The rate has declined rapidly in the past 90 years, however. Uncontrolled bores and excessive water extractions from the GAB have reduced artesian water pressures by over 80 m in some locations and significantly reduced flow from its springs (see 'Aquatic ecosystems—wetlands', page 5.27). About three-quarters of the 240 spring groups recorded no longer flow and the remaining active springs have substantially reduced flows. Figure 5.2 shows the historical trend of artesian bore flow from the GAB.

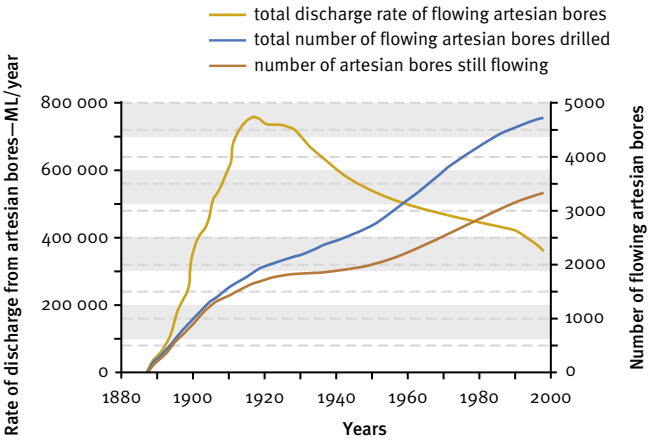


Figure 5.2 *Historical trend of artesian bore flow from the Great Artesian Basin*
Source: DNRM

Responses

Number of artesian bores capped and bore drains replaced

In 1989, the Great Artesian Basin Rehabilitation Program was initiated to repair, cap or replace bores flowing uncontrollably. Under this program, 347 bores were rehabilitated and 2078 km of bore drains replaced. Since July 1999 the Commonwealth and Queensland governments have funded projects under GABSI, carried out by landholders. GABSI provides financial and technical assistance to rehabilitate bores and replace bore drains with piped systems. It aims to encourage the sustainable use of GAB groundwater, and consequently to maintain and enhance the social, economic and environmental values of the basin.

Since GABSI began, an additional 69 bores have been rehabilitated and a further 1747 km of bore drains have been replaced. The works undertaken between 1989 and 2002 have resulted in water savings of over 80 000 ML a year. The rate of pressure decline has fallen in many parts of the basin and a long-term pressure recovery of 5 m is expected. Figure 5.3 shows the typical recovery pressure contours resulting from the first two years of GABSI.



Rehabilitation of bores on the Great Artesian Basin is continuing to reduce waste of groundwater. (Photo: DNRM)

Case study: Great Artesian Basin Sustainability Initiative

The Great Artesian Basin Sustainability Initiative (GABSI) is a strategy developed by the Great Artesian Basin Consultative Council (GABCC). Through GABSI, the Commonwealth has committed $31.8 million over five years from 1999 for bore rehabilitation and bore drain replacement programs. This package is delivered through state agencies and builds on previous incentive programs. Queensland matches the Commonwealth contribution and the funding is used to finance projects that will improve groundwater management and water use at a property level. Landholders can undertake projects involving bore rehabilitation, bore drain piping, or both, through GABSI. Although project costs are subsidised by the State and Commonwealth governments, landholders also contribute substantially.

Landholders in the GAB have had the opportunity to learn more about the benefits of bore capping and piping to their property management, the community and the natural resource at a number of field days held by the Queensland Government. One such, 'Planning for Sustainable Natural Resource Management Field Day', recognised the first artesian bore piped in Queensland (DPI 2001). Many landholders have already benefited from the initiative and some are taking part in the field days to discover how the program works and the benefits to be gained from participation.



Landholders in the Great Artesian Basin can learn more about the benefits of bore capping at field days held in their region. (Photo: DNRM)



Aboriginal rock well, St George (Photo: DNRM)

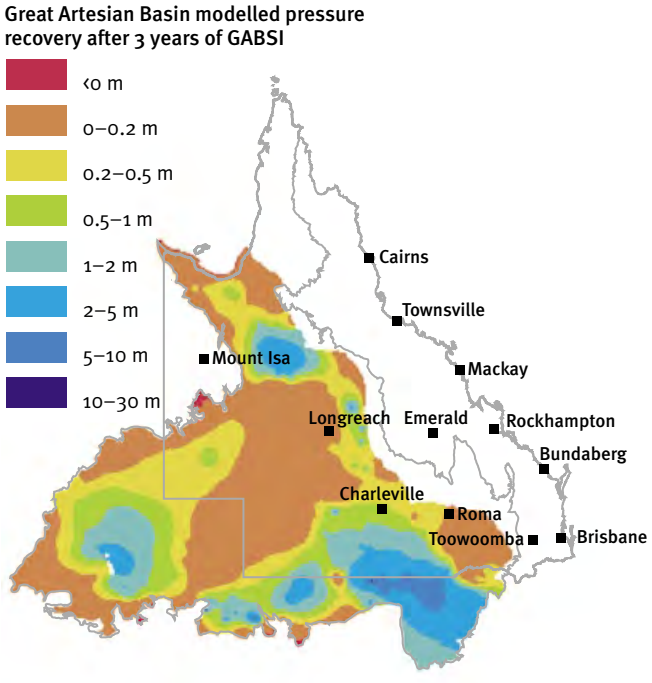


Figure 5.3 *Typical recovery pressure contours resulting from the first two years of GABSI*
Source: DNRM 2002h

Summary of condition and trend indicators

Groundwater—artesian bore pressure

GMU	Indicator Trend in artesian bore water pressure
Surat	▲
Warrego	▲
Flinders	▲
Barcaldine	▼
North West	▼
Gulf	▼
Central	▼
East	▼
Great Artesian Basin	▼ 416 bores capped + 4156 km of bore drains replaced to June 2002

Key to condition:

- **Good** minimal pressure reduction within aquifers
- **Moderate** significant pressure reduction within aquifers
- **Poor** very significant pressure reduction within aquifers
- **Not assessed**

Key to trend:

- ▲ Improving bore pressure
- ▼ Declining bore pressure

Groundwater quality

Summary

Australia's groundwaters are of many types and incorporate many physical, chemical and biological environmental components, both human-induced and natural. The potential for groundwater contamination is greatest where watertables are shallow, particularly if the land above the aquifer is sandy, with a history of development and unnatural changes to the watertable resulting from activities such as clearing or irrigation. Improved dam construction standards and strict monitoring of mine tailing dams have reduced events of localised contamination from leaching (EPA 1999a). Saltwater intrusion is a major threat for coastal groundwaters and some irrigation areas. The National Action Plan for Salinity and Water Quality (NAPSWQ) aims to reduce the risk of salinity outbreaks and deal with water quality issues.

Description

Groundwater is classified as any water that is stored below the root zone, but in reality there are several distinct aquifer types. Aquifers can be classified as shallow, deep alluvial, fractured rock, artesian or coastal. Surface activities and hydrological stress have different water quality implications for each aquifer type. As well as inherent differences in pollution vulnerability, each type of aquifer is also prone to a range of natural inherent water quality problems. Figure 5.4 shows the characteristics of each main aquifer type; vulnerabilities have been determined according to principles expressed in Vrba and Zaporozec (1994).

Groundwaters are naturally higher in salts than surface waters, and are also much more variable in salt content. Irrigation practices can increase groundwater salinity, which can damage soil and crops as well as rendering the water unpalatable for humans and stock. Nitrates may survive longer in groundwater than in surface water, but only if they are able to pass rapidly through the root zone before they are taken up for use by the plant. In high concentrations, nitrates can be harmful to human and animal health. Corrosiveness is a naturally occurring phenomenon in deep groundwaters, which have been oxygen-depleted and carbon dioxide-enriched. Corrosiveness is particularly likely to develop in low-salinity groundwaters, which flow through sandy geology without soluble minerals. Corrosive water is more likely to dissolve toxic levels of heavy metals, and hence may be unsuitable for domestic or stock supply, or disposal to the environment.

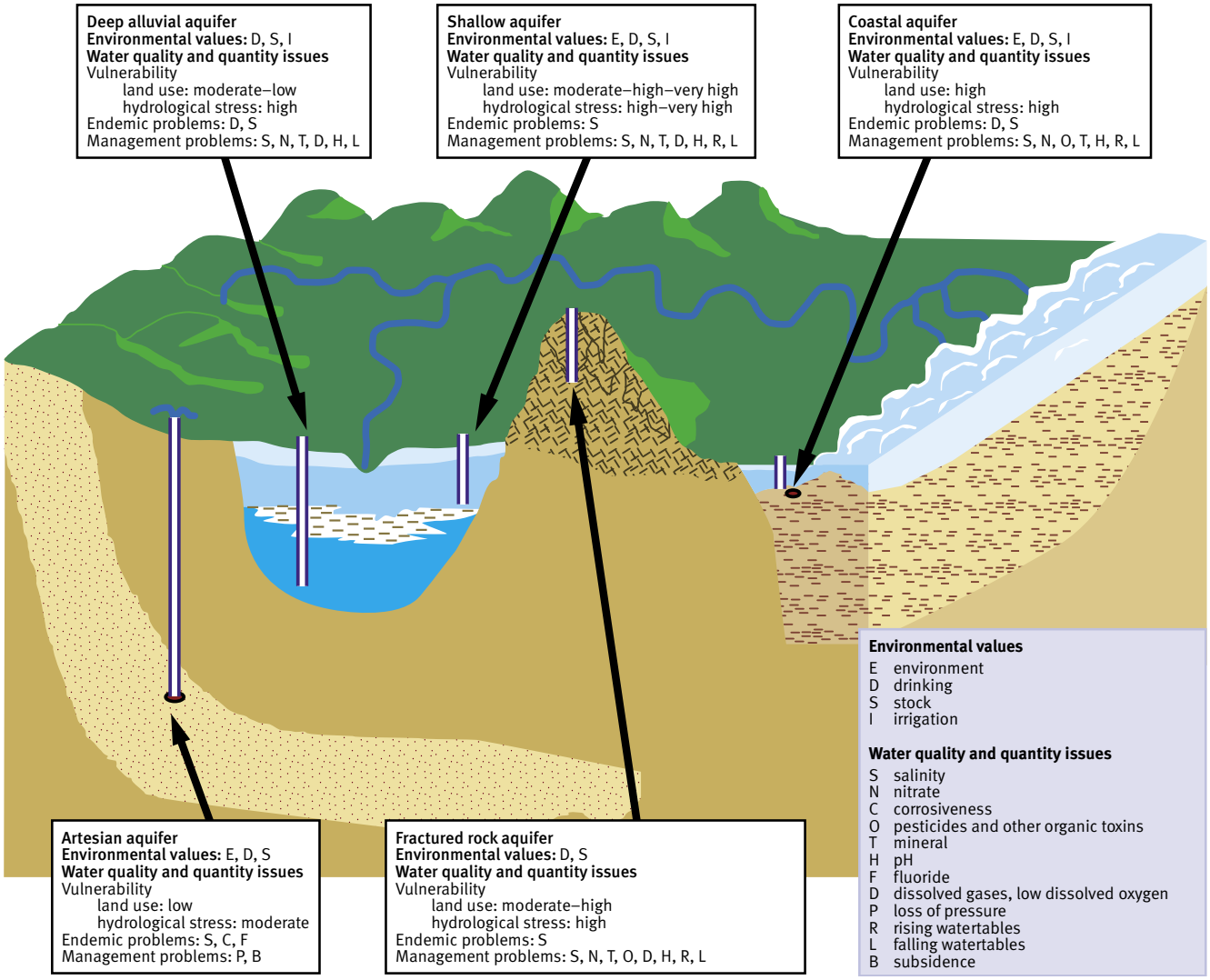


Figure 5.4 *Characteristics of the main aquifer types*
Source: DNRM

Pressures

Land clearing

Land clearing can result in rising watertables, which mobilise natural salt stored below the root zone. The impacts of land clearing on groundwater can have a lag period of up to 30 years before their full magnitude becomes apparent (see Chapter 4, 'Land').

Areas of rural or urban development

Direct pollution through the soil, from fertiliser and pesticide applications, septic tank effluent, landfills and seepages from intensive animal husbandry, has the potential to threaten groundwater. Urban development is expanding, especially in coastal zones and near waterways (see Chapter 4, 'Land').

Intensive use and changes in recharge patterns

Groundwaters below irrigation areas are prone to increasing salinity if they rise due to the addition of excess irrigation water, or fall as a result of excess extraction. Stream regulation also has impacts on the amount of water available for recharge, and particularly affects shallow aquifer types.

Aquifer vulnerability

Groundwater in shallow aquifers is more susceptible to direct pollution from the surface. In contrast, waters from the GAB may be thousands of years old and at depths of hundreds of metres. Artesian water quality may still be affected to some extent by hydrological changes. Aquifer vulnerability is quantifiable and is currently being mapped in Queensland.

Natural water quality

Specific Queensland aquifers are prone to a number of natural water quality problems. These include high salinity, sodium and fluoride levels, which have been relatively well quantified. Others, such as high and low pH levels, physical corrosion factors and iron bacteria, have not been effectively monitored or reported on except locally.

Condition and trends

Salinity

Groundwater in parts of inland catchments such as the Fitzroy, Burnett, Condamine and Lockyer basins has naturally high levels of salinity and hardness, as does the GAB. Salinity levels may also be increasing in parts of heavily used aquifers that are in hydrological contact with the coast, or within irrigation areas where recharge is limited. Dryland salinity occurs where rising watertables bring stored salt to the land surface, where it reduces soil productivity and may affect stream salinity. Similar effects result from prolonged irrigation with poor-quality groundwater. Extensive drilling now being carried out through the NAPSWQ may reveal incipient saltwater encroachment in the future. Electrical conductivity, measured in microSiemens per centimetre (µS/cm), is an indicator of salinity.

Nitrate and other problems

Nitrates can survive if they are able to pass rapidly through the root zone. Accordingly, high nitrate levels indicate zones of rapid recharge, which are also vulnerable to pollution from other sources such as pesticide application, but no widespread areas of pesticide or other organic pollution have been reported in Queensland groundwaters to date. Historically, high nitrate levels have been a frequent but sporadic finding in some fractured rock areas such as the Toowoomba basalts, and in some irrigated alluvials such as the Lockyer Valley. Such vulnerable aquifers may respond to land management. Some low-salinity northern aquifers and southern sand islands show raised levels of nitrate, and the water is prone to corrosiveness due to its low buffering capacity. The possible influence of acid sulfate soils should also be considered in coastal zones.

Water quality in the GAB is generally good, but local problems include salinity, fluoride and corrosiveness, all of which are endemic.

Corrosiveness

This condition occurs naturally in deep carbon dioxide-enriched, oxygen-depleted groundwaters. It is particularly likely to develop in low-salinity groundwaters that flow through sandy materials without soluble minerals. Bores in the northern and western GAB are known to be at risk. Corrosiveness is not generally affected by land use, unless watertables are disturbed in acid sulfate soil areas. Another cause of corrosion in bores is iron bacteria. They are damaging when excess withdrawal causes water to cascade in the bore, increasing levels of dissolved oxygen. If drilling is carried out in an area prone to corrosive water, the bore and all of its equipment must be composed of suitable materials. Corrosive water is also more likely to dissolve toxic levels of heavy metals, and so should be tested before use as a domestic or stock supply or disposal to the environment.

Responses

National Action Plan for Salinity and Water Quality

On 1 March 2002 Queensland signed a bilateral agreement formalising arrangements between the state and Commonwealth on the National Action Plan for Salinity and Water Quality (NAPSWQ). Despite the fact that Queensland does not have a salinity problem of the same magnitude as other states, there is potential for significant increase if no action is taken. The aim of the NAPSWQ is to reduce the risk of salinity outbreaks and to deal with water quality issues (DNRM 2002c). The Queensland Government has developed a salinity hazard mapping methodology for dryland and irrigation salinity, which has been used in the Queensland Murray–Darling Basin and will now be used in other NAPSWQ priority catchments (DNRM 2002c).



Groundwater monitoring (Photo: M. Nemeth, DNRM)

Case study: Saltwatch

Saltwatch is an annual event that involves the Queensland community in monitoring, taking action on and learning about salinity as a serious natural resource management issue. Saltwatch has been operating in Queensland since 1991. In 'Saltwatch Fortnight', each May, samples of water from bores and other sources are collected and tested to determine the level of salinity. Queensland Government scientists collate the results to gauge the extent and trend of salinity throughout the state.

Thousands of schools, individuals and community groups have been involved in Saltwatch since 1991. Involvement of the community in monitoring assists with the identification of existing and emerging saline sites and landscapes, and helps community groups develop, implement and monitor strategies to tackle salinity programs. In 2001, Saltwatch attracted significant media coverage, as it celebrated its 10th year. Individuals from as far west as Quilpie and as far north as Burdekin participated in the Saltwatch event. A brochure, *Snapshot on Salt*, was developed, describing the results of the program over its lifetime. The brochure highlighted the fact that groundwater is inherently more saline than surface water through natural processes including weathering and evaporative concentration. The majority of samples from Saltwatch indicate a groundwater quality of less than 2900 µS/cm, which is suitable for most uses, but not as a long-term source for human consumption. The quality of groundwater from northern Queensland is significantly different from that of southern Queensland; northern and central coastal catchments have predominantly fresh groundwater, and the Fitzroy, Murray–Darling and south-east coastal catchments show more evidence of moderately saline groundwaters.

Summary of condition and trend indicators

Groundwater quality

Groundwater management unit	Water quality condition	Comments
Lockyer Valley		Saline and hard; nitrate may be excessive for drinking; condition is stable
Condamine Alluvial System		Saline and hard
Darling Downs Basalts		Hard, and nitrate may be excessive for drinking; may respond to land management
Atherton Basalts		May be corrosive and vulnerable to land use
Burdekin Delta		Saline and hard; local saltwater intrusion; unsuitable for salt-sensitive crops
Burdekin Irrigation Area		Saline and hard
Bowen		Saline and hard; unsuitable for salt-sensitive crops
Pioneer Valley—Bakers Creek		Hard; local saline intrusion; nitrate may be excessive for drinking; may respond to land management
Pioneer Valley—Marian		Hard; local saline intrusion; nitrate may be excessive for drinking; may respond to land management
Callide Valley		Saline and hard; may respond to land management
Dee River		Saline and hard; may respond to land management
Bundaberg Irrigation Area—Gooburrum		Corrosive; nitrate may be excessive for drinking
Bundaberg Irrigation Area—Woongarra		Corrosive; nitrate may be excessive for drinking
Great Artesian Basin		Fluoride may be excessive for drinking and stock; waters may be corrosive

Note: Each water quality sample was compared to guidelines (ANZECC and ARMCANZ 2000) and labelled as either above or below the value for each available indicator. The number of indicators exceeded by the sample was tabulated for each environmental value, and the proportions were then listed for the individual GMUs.

Key to condition:

Good	0–20% of samples exceeded guidelines for indicators
Moderate	20–50% of samples exceeded guidelines for indicators
Poor	>50% of samples exceeded guidelines for indicators

Surface water quantity

Summary

Because of low rainfall in recent times, attention has been focused on sound water quantity management. As the fastest growing state in Australia, Queensland faces increased demand for water from all user groups, a demand exacerbated by the current climatic conditions. Overall surface water management at the national level falls within the COAG water reform framework, which embodies initiatives such as the National Principles for the Provision of Water for Ecosystems (ARMCANZ and ANZECC 2002). Queensland has established a comprehensive basin-level planning framework that deals with the management of surface water quantity. This framework is firmly based on science and community consultation. The water planning process is supplemented by a number of whole-of-government strategies that tackle the issue of better management of water use.

Description

As the scale of water resource developments has increased to meet social and economic needs, impacts on the ecology of waterways and other water-dependent ecosystems have become more evident. There have been changes to river condition over time. The natural seasonal and annual variability of water regimes, which are essential for the maintenance of the health of Queensland's native aquatic ecosystems, have been modified, particularly where development is greatest. In general, medium and low flows have been altered the most, as water is stored behind dams or extracted from watercourses. Conversely, low flows may be increased as natural flows are supplemented with releases from storages during times of irrigation need. Some impacts, especially those at locations at or close to major infrastructure, have been immediate and obvious. Other impacts have been more gradual, the changes becoming apparent over time.

There is an obligation to advance the sustainable management and efficient use of surface water and groundwater resources by establishing systems for the planning, allocation and use of these resources, while protecting the biological diversity and health of natural ecosystems. This is being achieved through detailed investigation of river and aquifer systems that are either significantly affected by or at risk from further land and water resource developments, and through statutory water resource planning and management processes and/or community-based natural resource management initiatives.

Pressures

Annual rainfall

In the period 1999–2002, annual rainfall in Queensland was greater than average in the north-west of the state, and below average in the south-east and some coastal centres. Rainfall for 2002, however, was well below average for the vast majority of the state. The below-average rainfall is reflected in the area that has been drought declared. In July 2001, 6% of Queensland was drought declared; by December 2002, this figure had climbed to approximately 50% (DNRM 2002b).



Water entitlements, to use water for purposes such as irrigation, are granted under the Water Act 2000. *(Photo: DNRM)*

Number of water entitlements

Water entitlements are granted under the *Water Act 2000* for the taking and use of water. In areas with supplemented watercourses, licences are issued on the basis of a maximum volume ('nominal allocation'). For streams that are unsupplemented, entitlements may be issued based on the size of the area being irrigated or, in some cases, on a volume. For this reason, it is not possible to state the total volume of water associated with entitlements.

The total number of water entitlements remained relatively stable over the period from 1998 to 2001, when 25 875 and 26 428 entitlements were held respectively (DNRM 2002d). The decline in the number of entitlements to 22 478 in 2002 (DNRM 2002d) may possibly be the result of recent changes in the way records are kept. The figures in part reflect the moratoriums on new entitlements in place as water resource planning continues. In a number of catchments, the water resource planning process has identified quantities of available but unallocated water. It is expected that there will be an increase in the total volume of approved allocations as these allocations are taken up.

Approval of major water storage infrastructure

New water storage infrastructure can further modify the flow of surface water from the 'pre-development' condition. Since 1999, approval has been given for two new dams and the raising of one dam, with a combined additional capacity of 1 670 000 ML. Two new weirs, and the raising of a third weir in the Burnett catchment, have also been approved; these have a combined additional capacity of 13 561 ML. The only significant infrastructure constructed in the period was the raising of Awoonga Dam on the Boyne River, near Gladstone.

Condition and trends

Ten-year mean annual flow

The mean annual flow (MAF), when expressed as a percentage of the pre-development MAF, gives an indication of the extent of consumptive water use in a catchment. Although this indicator is not very sensitive to annual changes, it gives a coarse indication of the extent of flow-related ecological risk associated with water resource use in a region. It should be noted that the most reliable data that can be presented are for those catchments that have a calibrated flow model (generally the catchments that have a high level of water resource development). For the purpose of this report, modelled existing authorisation conditions have been compared with modelled pre-development conditions.



Infrastructure, such as the Gorge Weir on the Burdekin River, is used to modify the flow of surface water. (Photo: DNRM)

The most recent ten-year periods with authorisation and flow information available were used in models. In most cases, periods did not extend to the present date, and therefore may not capture recent changes. Because a ten-year timeframe has been used, the numbers are different from those adopted in the water resource planning process, which is based on a longer record. Note also that this statistic is subject to a high degree of fluctuation in ephemeral systems, such as those that occur in the south-west, making it questionable as an indicator in such systems (see, for example, Cullen et al. 2003). Further research is under way to develop more robust hydrologic indicators and to pursue more environmentally attuned event-based management approaches in south-western streams.

Most of the Queensland rivers for which data are available fall into the relatively low risk MAF category. Noting the above limitations, the Macintyre and Moonie catchments would be categorised as relatively moderate, and the Condamine and Kolan as relatively high risk, warranting more sophisticated management responses.



The patterns of natural river flows, such as the Jardine River in Cape York Peninsula, are essential for maintaining aquatic ecosystem health. (Photo: L. Knight, EPA)

Ten-year annual proportion of flow deviation

Annual proportion of flow deviation (APFD) is a flow statistic that is an ecologically meaningful measure of flow regulation (Gehrke et al. 1995), where a totally natural flow regime results in an APFD of zero. APFD is particularly sensitive to changes in both flow seasonality and volume. Like MAF, APFD is generally known for those catchments with significant water resource development. As was done for MAF, the statistic was calculated by comparing modelled flow data with modelled pre-development flow data for the most recent ten-year period for which data were available.

In terms of APFD, the Haughton, Kolan, Macintyre, Moonie, Condamine and Warrego catchments are regarded as poor, although the result for the Warrego seems anomalous. The Gregory, Isis, Bulloo and Paroo rivers are regarded as good, and other rivers for which data are available are regarded as moderate.

Storage capacity

Queensland's high rainfall variability has resulted in the construction of dams and weirs to store water for periods when rainfall is insufficient to meet requirements. Coastal streams, which are more perennial, tend to have storages instream, whereas the western streams are drier and private off-stream storages dominate. Queensland has almost 200 major instream reservoirs, which supply approximately 65% of the state's total surface water consumption. These have a combined capacity of approximately 10 million ML (DPC 2002). Most off-stream storages are not licensed; consequently, few records are available. Information collected for the Condamine-Balonne catchment shows that off-stream storage capacity in the catchment increased from 107 000 ML in 1992 to 1 145 000 ML in 2000 (DNRM 2002e).



Private off-stream storages (dams) dominate in western Queensland. (Photo: DNRM)

Water use by sector

In 1996–97, an estimated total of 2 969 000 ML of surface water was used in Queensland, a 145% increase from the 1983–84 level. The increase chiefly reflects increases in irrigated agriculture (NLWRA 2001). Surface water accounted for approximately 65% of total water use in the state. The largest diversion of surface water was for irrigation (73%); urban and industrial use accounted for 26%; and other use by the rural sector accounted for 1% of the total (NLWRA 2001). Surface water use varies with seasonal irrigation demand. When rainfall is low, water withdrawal may be comparatively high; the opposite situation is most likely in years when rainfall is abundant, as less water is withdrawn.

Water use for irrigation by crop type

The sugar and cotton industries are the largest users of irrigation water in Queensland, and in 1996–97 accounted for approximately 62% of total water consumption. Collectively, 'vegetables, fruit, grapevines, livestock, pasture, grains, cotton and other agriculture industries' accounted for approximately the same amount of water use as the sugar industry. The sugar industry is by far the largest consumer of water in Queensland, having an average yearly consumption of approximately 1 300 000 ML. As well as being the largest net user of self-extracted water, the sugar industry is also one of the state's largest users of water provided by channel supply systems (~300 000 ML/year, or 20% of the total) (ABS 2000).

Responses

Water resource planning

The Queensland Government, through the *Water Act 2000*, has introduced a water resource planning process designed to provide for the allocation and sustainable management of water to meet the state's future water requirements, including the protection of natural ecosystems and security of supply to water users. These plans involve consulting with the community and stakeholders to identify water allocation and management issues within river catchments. Regulation of overland flow and groundwater is an essential factor within the boundaries of certain areas. Information relating to the volumes of water allocated is expected to improve as more licences are converted to a volume basis with the roll-out of the water planning process across the state.

Improvements in water use management

The Queensland Government has fostered partnerships with the sugar, cotton, dairy and lucerne industries through Rural Water Use Efficiency Initiatives (RWUEIs). Over 3500 applications have been approved, and irrigators have invested $7 million in changing to more efficient irrigation systems (DNRM 2002c).

Further, the government embarked on a water awareness program in 2002, leading into 2003, which was declared by the United Nations as the International Year of Freshwater.

The government has introduced land and water management plans to minimise the adverse environmental impacts of the development of land and water resources. The plans are property-based and describe infrastructure, natural resources and management practices in the use of land and water resources. Their purpose is to provide certainty that water allocated by government will be used in a manner that does not cause degradation of land or water resources, and to provide individual landholders with an effective farm management plan that demonstrates that irrigation farming practices are sustainable, both on- and off-farm.

The government has a number of programs that encourage various industries to follow 'cleaner production' principles, which include minimising the use of natural resources such as water.

The Queensland Water Recycling Strategy was released by the government in October 2001. It is an initiative to encourage water recycling that is safe, environmentally sustainable and cost-effective. It also takes into account the fact that in 2001 less than 10% of the 300 000 ML of effluent produced in Queensland was recycled.



Sunflowers growing on irrigated cropping land (Photo: L. Knight, EPA)

Case study: Improving water use efficiency

The Rural Water Use Efficiency Initiative (RWUEI), in conjunction with the sugar industry's COMPASS (Combining Profitability and Sustainability in Sugar) program, which aims to improve sustainability of the sugar industry while at the same time improving farm profitability, successfully fostered an industry, community and government partnership to bring about irrigation efficiency reform in that industry. A key assessment criterion of the sugar industry's efficiency of water use is an index of productivity based on the amount of water used by the crop. In all regions, the target set for 2001–02 was exceeded, in some areas by a wide margin. After seasonal adjustments, this increase in efficiency equates to an annual water saving of approximately 63 000 ML and an extra $40 million of cane production a year.



Sugarcane and cotton are the two largest users of irrigation water in Queensland. (Photo: DNRM)

Summary of condition and trend indicators

Surface water quantity

NRM region	NRM catchment	Indicator				
		MAF[a] (% natural MAF)	APFD[b]	Instream storage capacity (ML)	Water withdrawal by sector	Water withdrawal for irrigation by crop type
Cape York	Endeavour	X	X	295	↑ (145% increase in water use from 1983–84 to 1996–97) Irrigation = 2162 GL Urban/industrial = 787 GL Rural = 20 GL Total use = 2969 GL	Sugar industry ↓ Cotton industry ↑ Livestock, pasture, grains, and other agriculture ↓ Vegetables, fruit and grapevines ↓
	Annan	X	X	380		
	Mission	X	X	250		
Northern Gulf	Mitchell	X	X	20 101		
	Norman	X	X	4 350		
	Gilbert	X	X	925		
	Einasleigh	X	X	20 726		
Wet Tropics	Barron	66	1.945	442 505		
	Johnstone	X	X	366		
	Tully	X	X	205 789		
	Herbert	X	X	9 454		
Southern Gulf	Flinders	X	X	22 600		
Burdekin Dry Tropics	Haughton	102	4.915	1 640		
	Burdekin	92	1.587	2 044 088		
	Ross	X	X	422 060		
Mackay–Whitsunday	Pioneer	91	1.851	164 700		
	Proserpine	X	X	491 400		
Fitzroy	Fitzroy	84	1.896	1 774 244		
	Dawson	X	X	220 994		
	Calliope	X	X	65 435		
	Boyne	X	X	250 000		
Burnett–Mary	Kolan	41	4.979	577 410		
	Burnett	75[c]	1.772[c]	534 742		
	Burrum	X	X	25 890		
	Elliott	78	1.774	1 197		
	Gregory	99	0.39	?		
	Isis	98	0.287	?		
	Mary	91[c]	0.925[c]	120 244		
South East	Logan	94	0.761	44 705		
	Albert	95	0.647	9 130		
	South Maroochy	X	X	5 451		
	Mooloolah	X	X	24 660		
	North Pine	X	X	230 500		
	Brisbane (incl. Lockyer)	X	X	2 234 392		
	Bremer	X	X	98		
	Warrill	X	X	84 053		
	Tallebudgera	X	X	363		
	Nerang	X	X	173 410		
South West	Macintyre	60	4.235	?		
	Bulloo	99	0.079	?		
	Moonie	64	3.357	?		
	Condamine	43	3.953	245 405[d]		
	Warrego	85	3.055	4 772		
	Paroo	99	0.074	?		

[a] Assessment criteria based on those proposed by Jones (2002):
>66% MAF = High probability of a healthy river
50–66% MAF = Moderate probability of a healthy river
<50% MAF = Low probability of a healthy river

[b] Assessment criteria based on those proposed by Ladson and White (1999):
APFD <0.5 = good
APFD 0.5–3.0 = moderate
APFD >3.0 = poor

[a, b] The most recent ten-year periods available were used in models. In most cases, periods did not extend to the present date and therefore may not capture recent changes in water use. Values will be a reflection of pressures within the ten-year period sampled; values may differ using long-term records such as those used in WRPs, which should be referred to for more detail.

[c] Gauging station upstream of major extraction of water

[d] Includes Balonne and Maranoa subcatchments.

Key to condition:

- High
- Moderate
- Low
- Not assessed

Key to trend:

- ? Not clear
- X Not assessed
- ↑ Increasing surface water use
- ↓ Decreasing surface water use

Surface water quality

Summary

Eutrophication, chemical contamination and salinity most commonly arise from urban and agricultural activities such as irrigation and fertiliser and pesticide applications. Regional assessments of nutrients and salinity undertaken to assess suitability for aquatic ecosystem protection revealed that levels were variable throughout the state. In general, Queensland's northern regions tended to be in better condition than southern regions, although only limited datasets were available for assessment in some regions. No statewide monitoring program of chemical contaminants is currently in place. Several national and state plans, policies and strategies have been formulated in response to these issues, many focusing on community involvement, for example, through integrated catchment management and the NAPSWQ. Under the *Water Act 2000*, the water resource planning process provides additional legal provision for the protection of the health of surface water ecosystems.

Description

Maintenance and enhancement of surface water quality are necessary to protect the many environmental services the water provides, to ensure adequate quality and availability of water for human use and to protect the health of aquatic ecosystems. Important environmental values include the protection of aquatic ecosystem health, drinking water for human use, recreation, livestock watering, irrigation and aquaculture. Water quality guidelines exist for each of these uses. The required qualities set out by the guidelines reflect the needs of different environmental values.

Healthy aquatic ecosystems are most commonly associated with high water quality. This is reflected in the threshold levels (or trigger values) for the maintenance and protection of aquatic ecosystems recommended by the Australian Water Quality Guidelines (AWQG) (ANZECC and ARMCANZ 2000), which in many cases are more stringent than those required for other environmental values. For the purposes of this report, the threshold levels for water quality reported are those advocated by the AWQG for the protection of aquatic ecosystem health.

The three main issues affecting surface water quality in Queensland's inland waters are considered to be eutrophication, chemical contamination and salinity. Along with physico-chemical indicators, macroinvertebrate species and algal blooms are monitored to determine water quality.

Pressures

Discharges of nutrients into waterways from point and non-point sources

Excessive enrichment of waterways by nutrients (eutrophication) causes changes in water quality and biological productivity. A troublesome consequence of the eutrophication of inland waters is the occurrence of algal blooms, which can upset the natural balance of aquatic ecosystems as well as being toxic in some instances. Nutrient input into waterways originates from a variety of sources that can be categorised broadly as point and non-point sources. While point sources may contribute only a relatively small amount of the total nutrients entering waterways, their impact may often be disproportionate, as flows are both concentrated and continuous. Point sources generally contribute more nutrients than non-point sources in drier years.



Different water quality values exist for different water uses, including irrigation, livestock watering, recreational use and human consumption. (Photo: DNRM)



Agricultural chemicals such as nutrients and pesticides can enter waterways and affect surface water quality. (Photo: DNRM)

Point sources of nutrients are well-defined and concentrated at discharge points such as sewage treatment plants (STPs), cattle feedlots, piggeries and some industrial discharges. Industrial discharges are relatively small in comparison with those from STPs and intensive livestock enterprises. Estimates suggest that the volume of discharge will increase in the future (DNR 2000).

Non-point sources of nutrients enter waterways through a variety of surface and subsurface routes, especially during storms and flood events. As agricultural activities account for around 84% of Queensland's land use, nutrient enrichment is most commonly associated with eroded soil, plant litter, livestock manure and fertilisers from rural lands. In urban areas, stormwater runoff transports nutrients in litter, soil and fertilisers from roofs, parks, gardens, roads, paths and gutters. Most stormwater flows untreated directly from drains into local rivers or creeks. Quantitative estimates can be found for a number of catchments in the National Land and Water Resources Audit (NLWRA 2002).

Discharges of contaminants into waterways from point and non-point sources

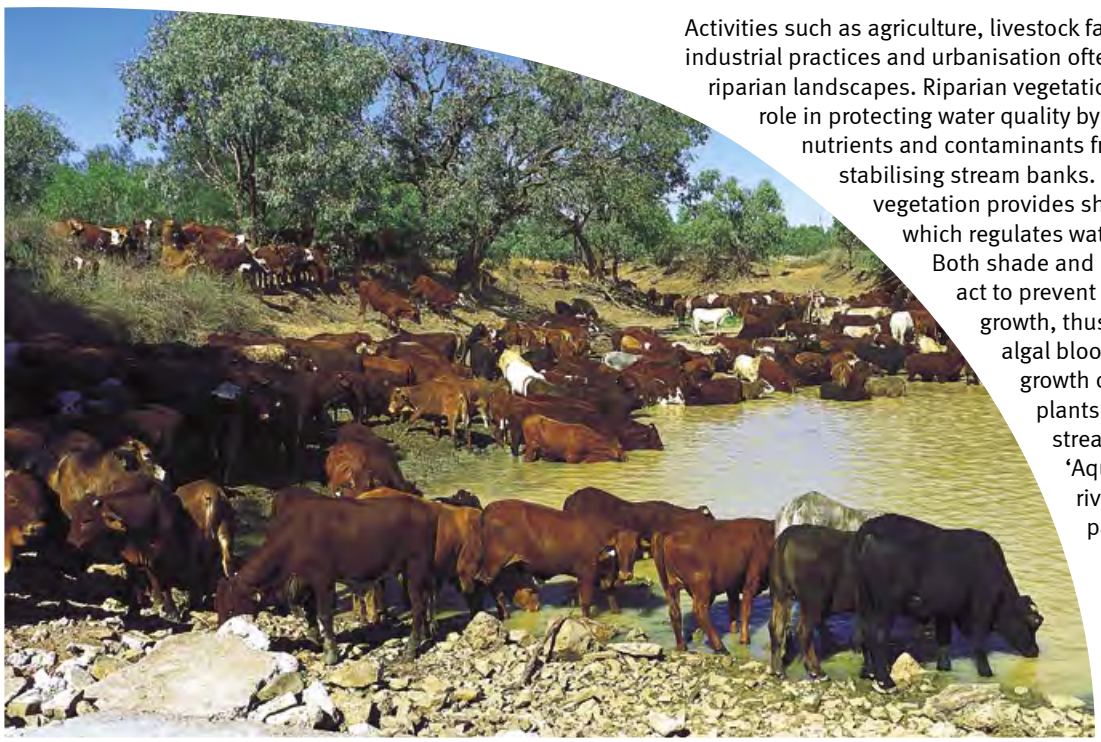
Pesticides and other chemical contaminants such as oil, paint, heavy metal compounds (mercury, copper, cadmium and arsenic, for example) and PCBs (polychlorinated biphenyls) can originate from agricultural, industrial and urban sources. They can have many deleterious effects on surface water quality and the health of aquatic biota, humans and livestock. Pesticides are used in many agricultural enterprises in Queensland, for example in the production of horticultural crops, cotton and sugarcane. In urban areas pesticides are commonly used to control household and garden pests. The risk of pesticides entering waterways tends to be greater when large runoff events occur soon after application. Mining and industrial activities have the potential to cause significant waterway pollution with chemicals and heavy metal compounds, but discharges from these sources are stringently regulated to mitigate any adverse impacts. Past mining practices may leave continuing legacies, however: for example, the Dee River is subject to copper sulfate leachate from the long-closed Mount Morgan mine site.

Land management practices

Dryland and irrigation salinity problems can be induced by practices such as land clearing or excessive water application, and can increase the amounts of dissolved salts entering adjoining rivers and streams. Salts can enter streams via groundwater seepage and spring flows, or when overland flows remove salts from the soil surface. While some inland waters are naturally saline, increased levels of salts in others can impair water quality and ecosystem health (see Chapter 4, 'Land').

Loss of riparian vegetation/condition

Activities such as agriculture, livestock farming and mining, industrial practices and urbanisation often alter or degrade riparian landscapes. Riparian vegetation plays a significant role in protecting water quality by trapping sediment, nutrients and contaminants from runoff and by stabilising stream banks. In addition, riparian vegetation provides shade to streams, which regulates water temperature. Both shade and lowered temperature act to prevent excessive algal growth, thus guarding against algal blooms and excessive growth of nuisance aquatic plants, which can clog stream channels (see 'Aquatic ecosystems—riverine habitat', page 5.23).



Livestock with direct access to streams can damage vegetation, expose the soil to erosion and increase sediment and nutrient loadings in the streams. (Photo: DNRM)

Livestock access to streams

Uncontrolled use of riparian lands by stock contributes substantially to the amount of sediments and nutrients entering waterways. Livestock trample and graze the vegetation, exposing the soil surface to erosion and contributing to stream sedimentation. Animal excreta further add to nutrient loadings where stock have direct access to streams.

Sand and gravel extraction

Dredging of material from the beds of water bodies can contribute to downstream sedimentation and turbidity, which, in turn, can have significant effects on surface water quality. Currently, the Queensland Government administers 240 environmental licences for dredging operations at 345 inland water sites.

River regulation and water abstraction

Most inland rivers in Queensland are slow-flowing due to the gradual slope of the land. River regulation to provide water storages in the form of weirs, dams and barrages reduces this flow even further. Many of the state's rivers are naturally turbid and this, combined with conditions of low flow, can give a competitive advantage to cyanobacteria (blue-green algae), which are favoured by such conditions. River regulation also significantly decreases the potential for variation in river flow, which is critical to maintaining biodiversity and the functioning of aquatic ecosystems (see 'Surface water quantity', page 5.11).

Recreation

Recreational activities such as fishing, boating, rafting, kayaking and canoeing attract large numbers of people to Queensland's streams, lakes and storage areas. They can have a number of impacts on water quality, through bank erosion caused by wave wash, and contamination from oil and fuel spills, litter and faecal matter. Other water-associated recreational activities such as camping and four-wheel-driving can also contribute to stream contamination when carried out without due care in areas adjacent to streams. The potential impacts of recreational activities are much greater where these activities are conducted in protected and/or environmentally sensitive areas, such as national parks.



Water storages, such as dams, are also used for recreational activities. (Photo: DNRM)

Condition and trends

The water quality assessment was based mainly on datasets collected by the Queensland Government. Instream measurements of the nutrients nitrogen (measured as total nitrogen), phosphorus (measured as total phosphorus) and salinity (measured as electrical conductivity) were assessed to develop site and regional condition ratings based on the Australian and New Zealand Environment and Conservation Council (ANZECC) and Agriculture and Resource Management Council of Australia and New Zealand (ARMCANZ) water quality guidelines for aquatic ecosystem protection (ANZECC and ARMCANZ 2000). Figure 5.5 shows the locations of the sampling sites.

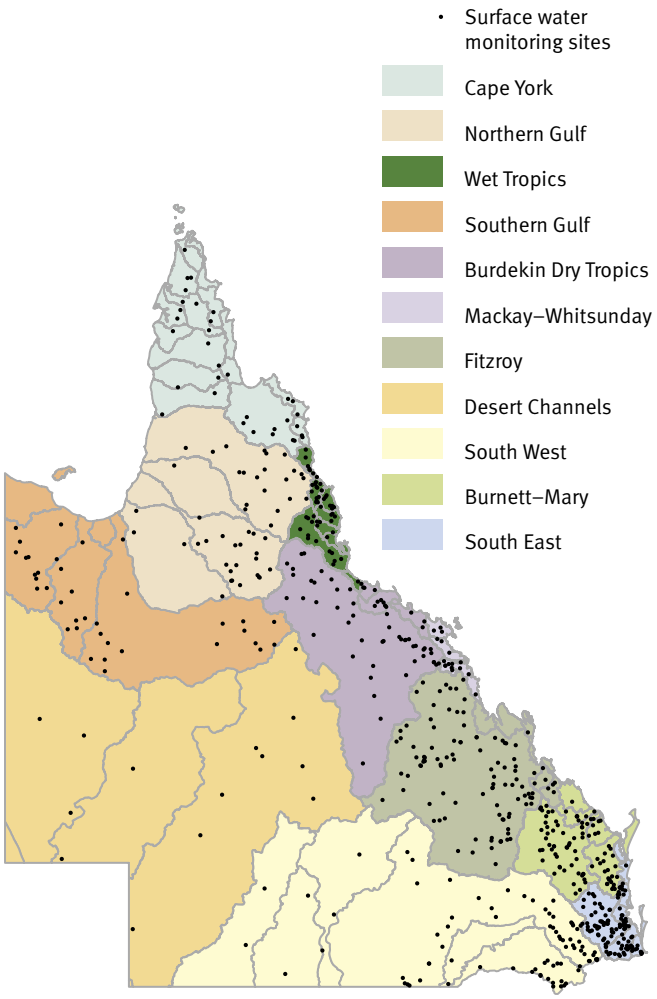


Figure 5.5 *Location of water quality assessment sites*
Source: DNRM

Nutrients

Levels of total nitrogen varied at sites throughout the regions, from predominantly good (sites in the Burnett–Mary and Cape York) to poor (sites in the Fitzroy and Burdekin regions). Statewide, levels of total phosphorus were generally rated as poor. Loads of sediment, nutrients and salt transported by inland waterways were not included in the assessment.

Pesticides

There is currently no routine statewide monitoring program for pesticides and other chemical contaminants in Queensland, but targeted studies have been conducted in several regions. The Condamine Balonne Water Committee (CBWC), over a number of years, conducted a project investigating the fate of nutrients and pesticides in the riverine environment.

The key findings (CBWC 2002) reveal a mixed result for the catchment's water quality. There were significant improvements in the levels of endosulfan detected: total endosulfan detections remained at zero for the last three sampling seasons. Metolachlor and prometryn detections increased significantly between 1993 and 2001. Atrazine was the most commonly detected chemical, found in 72% of the samples analysed, followed by metolachlor, detected in 65% of the samples. Detections of these chemicals were particularly high in summer months when their use was highest, as was rainfall. Levels also frequently exceeded the National Health and Medical Research Council and ARMCANZ drinking water guidelines (NHMRC and ARMCANZ 1996) in the untreated storages that supply raw water for town water supplies.

Salinity

Electrical conductivity (EC) is a measure of the concentration of total dissolved salts in water and thus serves as an appropriate indicator of salinity in water. Salinity levels were variable throughout the regions, but in general salinity was less significant in the northern regions than in other parts of the state.

Algal blooms

Cyanobacteria (blue-green algae) are common and naturally occurring throughout the state. *Cylindrospermopsis raciborskii* is the most common and potentially toxic bloom-forming cyanobacterial species. Routine monitoring has detected this species in 70% of the state's reservoirs, at least on a seasonal basis. Algal blooms usually occur during the summer, when the use of reservoirs is greatest. The ingestion of algal cells and/or algal toxins through drinking or recreation has the potential to affect human health. Where a cyanobacterial bloom has affected a water body, local governments play an important role in managing the overall risks that the affected water presents.

Macroinvertebrates

Aquatic macroinvertebrates occupy a central role in the ecology of rivers. They are a key link in the food chain, forming a pathway between primary producers (such as algae and aquatic plants) and predators (such as fish, platypus and birds). These species do not move long distances and some of them are very sensitive to flow conditions, water quality and habitat condition, which makes them good indicators of local water quality impacts.

Models developed for the Australian Rivers Assessment System (AusRivAS) program use physical characteristics of river sites to predict the aquatic macroinvertebrate fauna that would be expected to occur if the sites were in a relatively unimpacted (reference) environmental condition. An assessment of the condition of a site is made by comparing the macroinvertebrate taxa predicted to occur by the models with the taxa actually observed at the site.

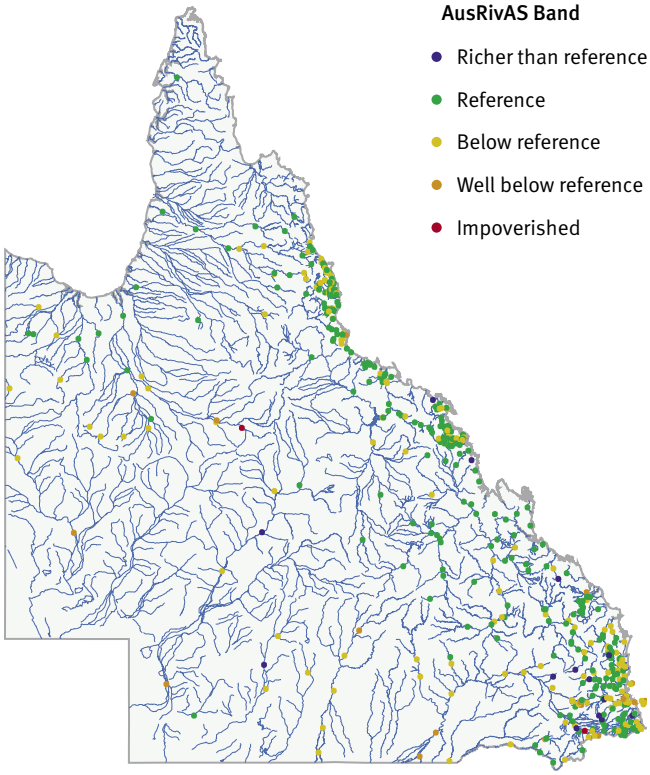


Figure 5.6 *Summary of macroinvertebrates survey results for all sites sampled throughout Queensland*

See page 5.22 for the national criteria used for this indicator to allow national comparisons.

Source: DNRM

Figure 5.6 shows the condition of all sites sampled throughout Queensland between 1994 and 2001 (other than reference sites used to develop the models). The majority of sites sampled were along the coastal rivers, corresponding to areas of intensive agricultural and urban use. Approximately half the sites in the south-east corner of the state were affected, while along the rest of the coast there were many fewer affected sites. The south-west parts of the state were predominantly affected, as were parts of the north-west. In headwater streams, the possibility exists that the rating is a reflection of the impermanency of the water body. In areas where the sites are mid-catchment, their rating is more likely to be a true reflection of the site condition.

Responses

Governments at all levels (Commonwealth, state and local) are now working in partnership with communities to tackle major water quality issues. Responses focus on four main areas:

- capacity building within regional community groups;
- development and implementation of natural resource management plans;
- provision of appropriate legislation; and
- adding to the information base and providing guidelines for management.

Recent major initiatives include the National Action Plan for Salinity and Water Quality, water resource plans, the Queensland Water Recycling Strategy and plans under the *Environmental Protection (Water) Policy 1997*.

In addition, information and guidelines on water quality management have been significantly enhanced through activities such as the National Land and Water Resources Audit, the National Water Quality Management Strategy (and associated Guidelines for Fresh and Marine Water Quality), and the National Pollutant Inventory. Queensland water quality guidelines are under development.

National Action Plan for Salinity and Water Quality

The National Action Plan for Salinity and Water Quality supports capacity building within selected regional communities and the development and implementation of natural resource management plans.

Water resource plans

The development of water resource plans (WRPs) under Queensland's *Water Act 2000* has made the first legal provision that adequate river flows be provided to maintain a healthy aquatic environment. WRPs are being developed for all regions.

Great Barrier Reef Protection Plan

The Queensland and Commonwealth governments have agreed to develop a Reef Protection Plan to protect the Great Barrier Reef from land-based sources of pollution. In relation to this, the Queensland Government recently released a draft Reef water quality protection plan. This plan is focused on improving the quality of water flowing from catchments adjacent to the Reef. Its implementation will be achieved through partnerships of multiple levels of government, industry and local communities.

Queensland Water Recycling Strategy

The Queensland Water Recycling Strategy encourages water recycling by governments, industry and the community. The strategy identifies ways to manage municipal, industrial and agricultural effluent and urban stormwater as resources, not wastes.

Plans under the *Environmental Protection (Water) Policy 1997*

Urban stormwater quality management plans

At present 64% of local governments in Queensland are at various stages in the development and implementation of urban stormwater quality management plans, as required by the *Environmental Protection (Water) Policy 1997*.

Sewage plans

Local governments are required to develop sewage plans for improved water management. No information on the status of these plans is currently available.

Case study: Fitzroy community setting high standards for water quality monitoring

Many people in Queensland are participating in community-based natural resource management and monitoring activities. One such activity is 'Waterwatch', which has 17 regional projects involving more than 4000 people in water quality monitoring at over 1150 sites. Waterwatch has several monitoring and educational projects operating in the Fitzroy Basin. Of particular interest is the Integrated Area-Wide Management (IAWM) project in Emerald, which started in 2002. IAWM is a joint initiative of the Cotton Research Development Corporation, the Queensland Government, 4T Consultants, SunWater and the Fitzroy Basin Association.

The main aim of IAWM is to provide land managers with better information and monitoring processes to assist in both production and environmental outcomes. The project is integrating information on landscape-scale water quality, land management and use, soils, topography, climate and pests into a database that cotton growers can use to improve their decision making.

As water management is a fundamental part of most agricultural production systems, many producers would like to have their own monitoring system that reliably informs them of the quality of their runoff water. Waterwatch programs have monitored several indicators in runoff and standing water for a number of years. As part of IAWM, landholders, the Waterwatch coordinator and IAWM project officers are testing a range of monitoring methods for each indicator to compare tools and identify those that work best in the field. This comparative study enables landholders to compare the relative merits of several options.



The Queensland Water Recycling Strategy encourages water reuse. (Photo: DNRM)

Summary of condition and trend indicators

Surface water quality

NRM region	Total nitrogen		Total phosphorus		Electrical conductivity	
	Condition	No. of sites	Condition	No. of sites	Condition	No. of sites
Cape York		1		1		12
Northern Gulf	Insufficient data			3		15
Wet Tropics		16		18		42
Southern Gulf	Insufficient data		Insufficient data			9
Burdekin Dry Tropics		1		3		32
Mackay–Whitsunday		3		4		13
Fitzroy		20		30		70
Burnett–Mary		4		8		60
South East		9		11		55
South West		6		27		40
Desert Channels	Insufficient data		Insufficient data			3

Pie charts indicate the proportions of sites in each region rated in good, moderate or poor condition for each parameter.

Key to condition:

Good <20% of samples at site exceeded guideline levels*

Moderate 20–50% of samples at site exceeded guideline levels*

Poor >50% of samples at site exceeded guideline levels*

*ANZECC and ARMCANZ 2000

Summary of condition and trend indicators

Macroinvertebrates

NRM boundary/catchment	Indicator: Macro-invertebrates AusRivAS (no. of sites)
Cape York	2
Northern Gulf	11
	7
Wet Tropics	51
	28
	1
Southern Gulf	8
	10
	2
	1
Burdekin Dry Tropics	31
	7
Mackay–Whitsunday	2
	35
	13
Fitzroy	1
	39
	7

NRM boundary/catchment	Indicator: Macro-invertebrates AusRivAS (no. of sites)
Burnett–Mary	2
	37
	15
	1
South East	5
	47
	38
	8
South West	3
	12
	28
	7
	1
Desert Channels	1
	2
	4
	2

Key to condition for macroinvertebrates (the national criteria are used for this indicator to allow national comparisons):

- Richer than reference
- Reference
- Below reference
- Well below reference
- Impoverished



(Inset photo) Macroinvertebrates, such as mayfly nymphs, provide important information on water quality. (Photo: DNRM)

(Main photo) Macroinvertebrate sampling, Albert River, south-east Queensland (Photo: M. Nemeth, DNRM)

Aquatic ecosystems—riverine habitat

Summary

The condition of aquatic ecosystems in Queensland is dependent, in part, on the extent and quality of the riparian vegetation and the extent to which physical river integrity is maintained. Riparian areas play an important role in trapping sediment and its attached pollutants, as well as providing habitat for native animals. As a consequence of the degradation of riparian vegetation, exotic species can often out-compete slower-growing native vegetation.

Community groups and governments have undertaken projects to rehabilitate riparian vegetation, prevent or control stream bank erosion, and fence streams to exclude stock. These projects have been supported through NHT funding and encompass the Landcare, Rivercare and Bushcare programs. The Queensland Government is developing riverine management plans to deal with instream activities that have impacts on river health, such as instream quarry material extraction.

Description

Riparian lands have a major influence on the health of aquatic ecosystems. These lands adjoin, directly influence or are influenced by a body of water. Riparian vegetation provides an important environmental service: it filters intercepted runoff, provides habitat for fauna and energy sources for instream functions, and helps to stabilise stream banks. In examining aquatic ecosystems, the riparian land, vegetation and water bodies should be treated together as a functional unit.

A well-vegetated riparian zone will generally protect stream banks from erosion, which is a major source of sediment. Sediment and its attached pollutants, such as heavy metals, pesticides and nutrients in water runoff, can be trapped and used by vegetation before it enters a stream. Riparian vegetation also plays an important role in the life history of many native animals and plants by providing shade, energy and habitat as well as wildlife corridors, allowing the movement of fauna and flora between remnant habitats.

Poor riparian condition is generally attributed to a reduction in natural riparian vegetation width as a result of clearing for urbanisation, agriculture or grazing. After disturbance, areas left to regenerate naturally are generally in the poorest condition. Vegetation removal and soil disturbance reduce the regenerative ability of native species and promote the invasion of exotic species. Introductions of weeds, especially aquatic weeds, affect water quality and irrigation efficiency, as well as recreational activities such as swimming, fishing and boating, by choking waterways. Further, disruption of stream flow leads to the fragmentation of river habitats and serial discontinuity of stream ecological processes. The presence of a single instream barrier can disrupt the movement of fish and affect the hydrology of the river through the change of flood frequency and flow patterns.

Pressures

Loss of riparian vegetation

Linear continuity and the width of the riparian vegetation zone are both very important to stream health, a fully vegetated zone providing maximum benefit. Generally, the wider the riparian vegetation, the better the filtering effect, widths of at least 30 m being considered necessary for streams adjoining most agricultural activities and also desirable to act as a wildlife corridor (Price and Lovett 1999). State of the rivers surveys (Anderson 1993; Carter 1997; Eberhard and Van Manen 2000, 2001; Henderson 2000; Johnson 1997, 1998, 1999; Moller 1996, 2000; Phillips and Moller 1994; Telfer 1995; Telfer et al. 1998; Van Manen 1999) have identified more than 20 000 km of stream length over 30 m wide. Widths of riparian zones in various catchments across Queensland are mostly less than 20 m except in the Desert Channels, the Northern Gulf, lower sections of the Queensland Murray–Darling and upper streams in the Burnett–Mary and Fitzroy regions. The South East NRM region has less than 500 km of stream length with riparian vegetation more than 20 m wide.

Decline of river physical integrity

Development throughout Queensland has resulted in construction of water supply infrastructure within streams. Beyond the requirement for larger community infrastructure, there has been extensive private development to meet individual property needs in the form of gully dams, off-stream storages and small weirs. Stream flow disruption is important in ecological processes because of the way dams, weirs and other structures impound water, change the flow patterns of streams, interrupt the movement of aquatic fauna and alter habitat availability within the streams. These factors lead to the fragmentation of river habitats and serial discontinuity of stream ecological processes (Fairweather and Napier 1998).

Queensland has over 900 water storages recorded on government databases. The more populated parts of the state have the greater number of infrastructure developments, which range from low tidal barrages at the estuary–freshwater interface, to very large dams for urban and industrial requirements. There are 115 dams and weirs in the South East NRM region. The region with the lowest number of structures is also one of the least populated, Desert Channels, which has 10 weirs and one dam.

Extent of deep-rooted vegetation

Over-clearance of riparian vegetation and its continued degradation through poorly managed grazing are primary causes of poor river health in Australia (LWRRDC 1999). The Queensland clearing rate in 1999–2000 was 758 000 ha, 78% higher than the 1997–99 average of 425 000 ha/year. Clearing in 2000–01 declined to 378 000 ha/year (DNRM 2002g). Approximately 68% of the 1999–2000 woody vegetation clearing occurred in areas mapped as remnant and 58% of the 2000–01 clearing was of woody remnant vegetation (DNRM 2002g). During this period 94% of the woody vegetation change was due to clearing for pasture, 2.3% for crop and the remaining 3.7% for forest, mining, infrastructure and settlement (DNRM 2002g).

Of the approximately 78% of the 1999–01 clearing that occurred in river catchments, 46% was in the Murray–Darling catchment and 16% in both the Fitzroy and Burdekin catchments (DNRM 2002g). (See 'Native vegetation clearing and modification', page 7.3.)

Condition and trends

Vegetated stream length

An indicator of the quality of aquatic habitats is the extent and condition of catchment and riparian vegetation where clearing has occurred. Through landscape clearing there is a potential for undesirable exotic plant species to intrude into native ecosystems and further diminish their value. Surveys of the riparian vegetation in many catchments across much of the state have revealed that more than half of the stream lengths surveyed are in poor condition. These ratings are attributed to general reduction in riparian zone width and the pressures to which the remnant vegetation is then subjected by grazing and other land use activities that change the structure of the vegetation communities.

Distribution of exotic species

After a disturbance opportunistic exotic plant species may establish and cultivated species may escape into wild populations. Data from the riparian vegetation surveys (Anderson 1993; Carter 1997; Eberhard and Van Manen 2000, 2001; Henderson 2000; Johnson 1997, 1998, 1999; Moller 1996, 2000; Phillips and Moller 1994; Telfer 1995; Telfer et al. 1998; Van Manen 1999) also provided information concerning the location of these exotic species. Commonly recorded species include rubber vine, lantana, parthenium, parkinsonia, hymenachne, cabomba, noogoora burr, groundsel bush, salvinia, water hyacinth and cat's claw creeper. The distribution of rubber vine and parkinsonia is thought to be increasing (see 'Weeds and pests' in Chapter 4, 'Land').



*Exotic species, including groundsel bush (*Baccharis halimifolia*), can invade riparian areas. (Photo: EPA)*



*The distribution of rubber vine (*Cryptostegia grandiflora*) is increasing. (Photo: EPA)*



Salvinia is an exotic water weed. (Photo: EPA)

All species show a tendency for regional concentrations (figure 5.7). Although lantana is widespread, it is not recorded in the inland-flowing catchments. The highest number and density of exotic weeds in the state have been recorded in the Fitzroy and central Burdekin River basins (NLWRA 2002). Coastal lowland areas of south-east, central and north Queensland also have significant weed problems. Weeds are said to be spreading into undeveloped areas of Cape York basins, including the Normanby and Jacky Jacky (NLWRA 2002).

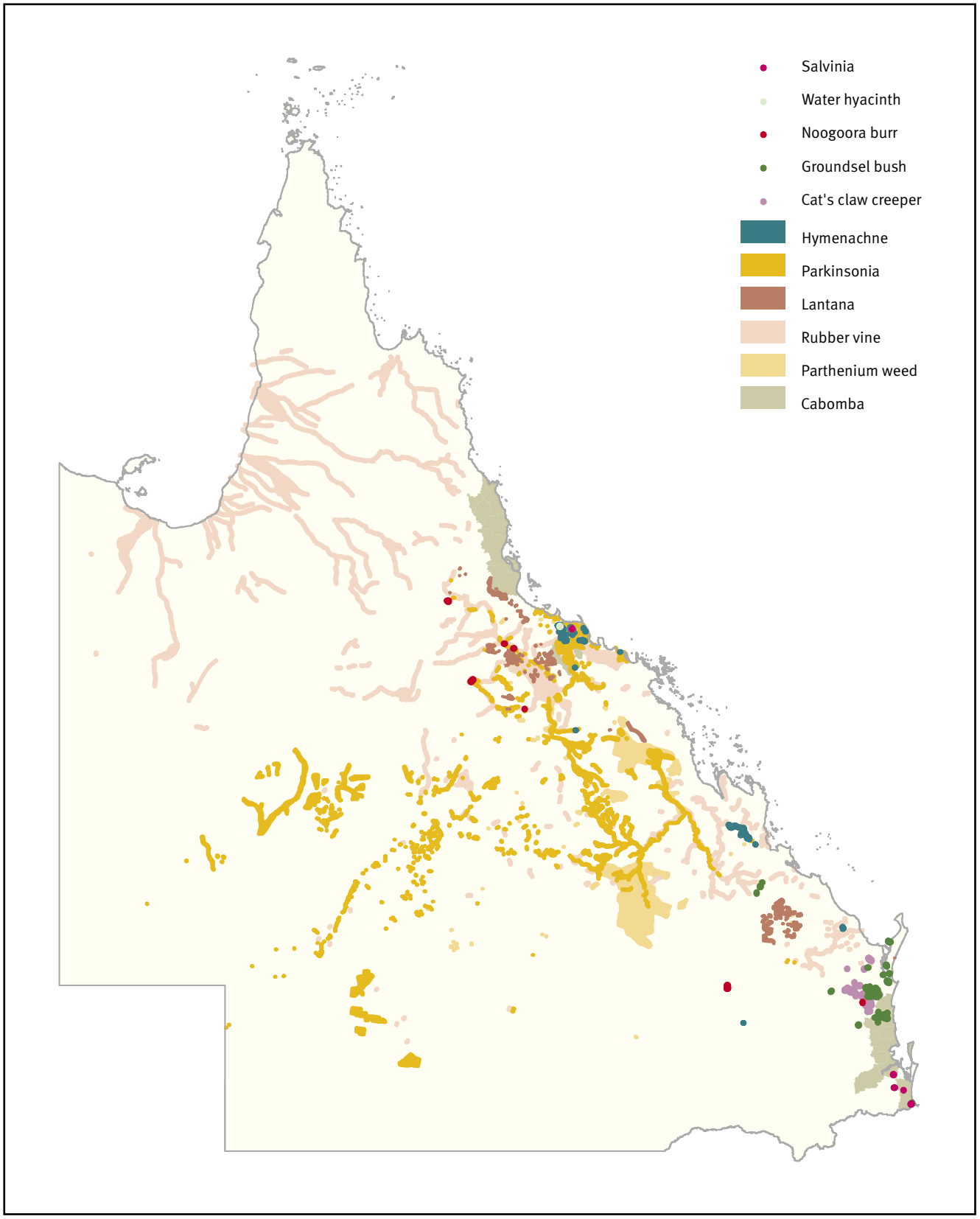


Figure 5.7 *Distribution of weeds affecting riparian areas in Queensland*
Source: DNRM 2002f

Responses

Natural Heritage Trust

The Natural Heritage Trust (NHT) was set up in 1997 to help restore and conserve Australia's environment and natural resources. Since then, thousands of community groups have received funding for projects dealing with these issues. The Queensland Annual Report for the NHT states that 454 projects were supported in 2000–01 across four programs, Landcare, Rivercare, Bushcare and Coastcare. Landcare supported 166 projects, Rivercare 64 and Bushcare 133. Many of the projects funded were for rehabilitation of riparian vegetation, prevention or control of stream bank erosion, fencing of streams to exclude stock, or regeneration of wetlands.

Riverine management plans

The Queensland Government is taking responsibility for advancing the stewardship of natural resources through development and implementation of riverine management plans. These plans take a whole-of-ecosystem approach to the management of instream activities such as extraction of riverine quarry resources. The Riverine Management Plan for the Logan River is expected to be completed by December 2004.

Queensland Weeds Strategy

The Queensland Government has released a state Weeds Strategy to guide the management of weeds until 2006. As part of this strategy, a new Land Protection (Pest and Stock Route Management) Act has recently been enacted to achieve better management of selected plant pests.

Case study: Tree planting program to stabilise river banks

The 'Tree Planting Program to Enhance River Bank Stabilisation' project has been established through the NHT. This four-year project is targeting eroding stream bank areas in the Mossman and Daintree river catchments. It has involved a mixture of river training and stream bank stabilisation techniques including rock groynes, fencing to exclude stock, erosion-control matting and revegetation. To date, stream bank rehabilitation at the Mossman River has been very successful, the site having survived three floods with no impact on the groynes or the tree plantings. The Daintree River site has also been successful, but is still being affected by boat wash. The project will now target priority areas for stream bank rehabilitation in the major catchments in Douglas Shire. The project will continue to trial a number of techniques to facilitate riverbank stabilisation. It will also contribute to improving both terrestrial and aquatic habitat values, reduce the impact of diffuse agricultural pollution and improve amenity for the river-based tourism industry.

Summary of condition and trend indicators

Aquatic ecosystems—riverine habitat

NRM region	NRM catchment	Indicator—vegetated stream length (km)		
		Riparian vegetation condition		
		Poor	Moderate	Good
Northern Gulf	Mitchell	933	1 191	10 066
Wet Tropics	Tully River	623	169	448
	Herbert River	2 133	229	193
Fitzroy	Dawson River	6 704	609	724
	Comet/Nogoa/Mackenzie rivers	5 582	1 582	3 975
Burnett–Mary	Burnett River	5 604	2 018	4 278
	Mary River	1 858	496	592
South East	Lockyer Creek	786	89	172
	Logan River	524	18	62
	Enoggera and Breakfast creeks	45	16	20
	Bremer River	537	136	83
	Maroochy River	459	19	39
	Mooloolah River	84	27	23
	Pumicestone Passage	306	231	243
	Lower Brisbane River	30	14	19
	Upper Brisbane River	38	19	6
South West	Maranoa and Balonne rivers	12 374	1 308	1 052
	Upper Condamine River	3 992	303	169
	Queensland Border Rivers	1 015	1 671	2 297
Desert Channels	Cooper Creek	3 851	1 952	3 936
Total		**47 478**	**12 097**	**28 397**

Key to condition:

Good 61–100% rating for assessment of width, structural form and species composition

Moderate 41–60% rating for assessment of width, structural form and species composition

Poor 0–40% rating for assessment of width, structural form and species composition

Not recorded

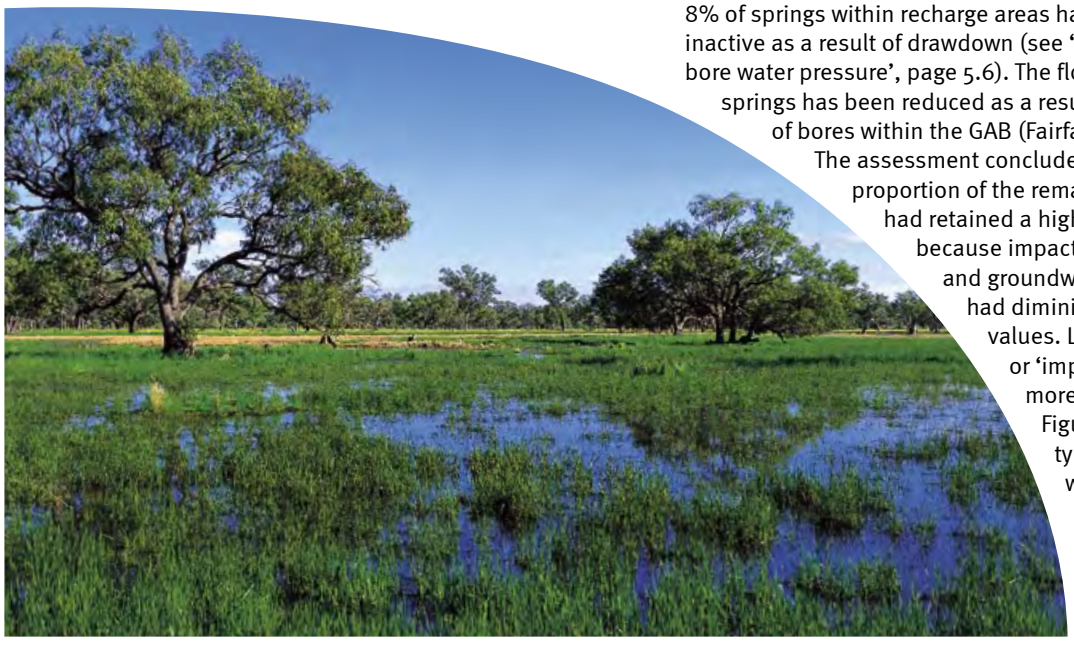
Aquatic ecosystems—wetlands

Summary

Wetland habitats and ecosystems form part of many landscapes and include a variety of features: rivers, lakes, swamps, springs, waterholes and water storages, such as dams and weirs. These areas play a key role in supporting a diversity and abundance of plants and animals and provide important habitat and refuges for many migratory, rare or threatened species. Legislation for their management is administered by various government agencies, some being administered jointly with Commonwealth agencies or local government. In order to overcome current deficiencies in information on the extent of the state's existing wetland resources, the Queensland Government has initiated an information database for their sustainable management. Important wetlands throughout the state have been mapped (EPA 1999a).

Description

Queensland has the most diverse array of wetlands in Australia. Of the 40 nationally recognised categories, all but one—alpine and tundra wetlands—occur there. The state differs from other parts of the world, particularly in the ephemeral nature of many of its freshwater wetlands, due mainly to its great climatic variation and seasonal variability. Queensland's wetlands support the most diverse freshwater fish fauna of any Australian state, providing essential habitat for the entire life cycle of 130 species. Its wetlands also support 150 species of waterbirds, both resident and migratory, and more than 3000 species of plants. Many species are considered rare or threatened, while others are economically valuable. Wetlands are an essential part of the natural hydrological cycle and purify water by stripping out nutrients and intercepting sediments. Wetlands make a significant contribution to Queensland's economic productivity by providing precious water resources for agricultural, urban and industrial uses, and supporting tourism and recreational activities. They are also significant in the cultural heritage, spiritual values and daily lives of Indigenous Traditional Owners.



Inland wetlands near Goondiwindi (Photo: DNRM)

Pressures

Loss of wetland areas to development

Queensland's increasing population and associated urban, industrial and agricultural expansion have placed increasing pressures on wetlands, and in some cases have resulted in the loss of wetland habitats. The loss of wetland habitats can occur directly through land reclamation or indirectly through impacts associated with adjacent use and management (EPA 1999a; DoE 1996). Major pressures are imposed by urban and agricultural development, grazing, feral animals and weeds, recreational activities, water pollutants and nutrients, and changes to hydrological processes. Although these pressures may not have a large impact individually, they can combine to result in large cumulative impacts to wetlands that can occur over relatively short periods. Additionally, smaller, more fragmented wetlands that may still have social, economic or ecological values can lose condition quickly when exposed to development processes (Blackman et al. 1999; Semlitsch and Bodie 1998).

Condition and trends

Area of wetlands

The extent of wetland loss in Queensland is largely unknown. Wetlands are currently estimated to cover approximately 4.1% of Queensland's mainland area, or nearly 71 000 km². Seasonally and intermittently inundated wetlands account for about 69% of the total, while tidal wetlands (mangroves and saline coastal flats) account for another 14%. Only 0.7% of Queensland's land area, or about 12 000 km², is permanently inundated; this area includes more than 1 125 000 km of major waterways. The remaining 17% covers a diversity of wetland types, including a large number of small spring-fed wetlands of high conservation value found within the GAB (Fensham and Fairfax, in press).

A recent assessment by the Queensland Government of the spring-fed wetlands within the Queensland portion of the GAB indicates that 62% of springs within discharge areas and 8% of springs within recharge areas have become completely inactive as a result of drawdown (see 'Trend in artesian bore water pressure', page 5.6). The flow of many remaining springs has been reduced as a result of the development of bores within the GAB (Fairfax and Fensham 2002). The assessment concluded that only a small proportion of the remaining spring wetlands had retained a high conservation value because impacts associated with land and groundwater management had diminished their biological values. Large artificial wetlands, or 'impoundments', number more than 250 (EPA 1999b). Figure 5.8 shows the major types and occurrence of wetlands in Queensland.



Spring (Photo: DNRM)

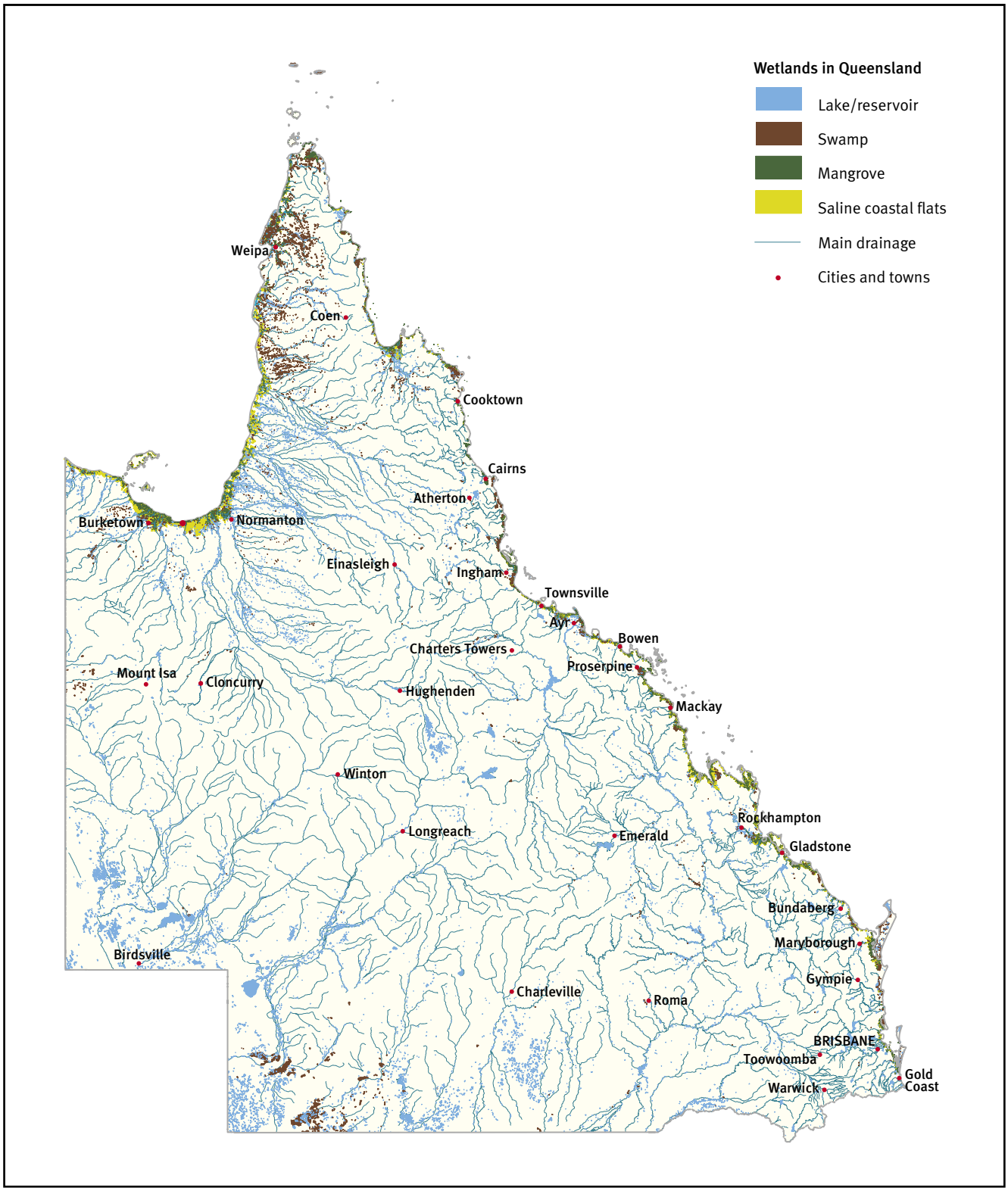


Figure 5.8 *Types and occurrence of wetlands in Queensland*
Source: EPA 1999b

Responses

Wetland database

The Queensland Government is currently building an information database to inform sustainable management initiatives by mapping the state's important wetlands (EPA 1999a). This document is being refined through additional mapping work in south-east Queensland, the northern section of the Brigalow Belt, the Desert Uplands and the Einasleigh Uplands, among other regions.



Loss of wetland habitats can occur directly through land reclamation or impacts associated with adjacent use and management, such as grazing. (Photo: L. Knight, EPA)

Wetland management

The challenge to conserve Queensland's wetlands is being met by government authorities in partnership with community groups. Forty-four state and Commonwealth statutory instruments and international agreements are being used to improve wetland conservation in Queensland. These include the *Environmental Protection Act 1994*, the *Environmental Protection (Water) Policy 1997*, the *Nature Conservation Act 1992*, the *Vegetation Management Act 1999* and the *Integrated Planning Act 1997*.

The Strategy for the Conservation and Management of Queensland's Wetlands (EPA 1999b) was endorsed by Cabinet in 1999. Although a number of actions have contributed to the implementation of the strategy, no formal implementation program has been undertaken.

Nature refuge agreements

Nature refuge agreements are negotiated between landholders and the Queensland Government to protect areas of conservation significance. These agreements do not exclude the use of land for agricultural production and do not interfere with the landholder's ownership or management of the area. A covenant attached to the title of the land conserves the defined area, regardless of future ownership. Landholders who enter into nature refuge agreements are entitled to tax deductions and may be eligible for financial assistance to support management of the area. Approximately 56 agreements were gazetted in the period 1999–2002. The amount of land protected under these agreements increased from approximately 2900 ha in 1999 to over 18 200 ha in 2002.

Case study: Wetlands in the Southeast Queensland bioregion

In 2002 the Queensland Government undertook a study of 17 wetlands within the Southeast Queensland bioregion; 10 of these were inland wetlands. The study found that inland wetlands have highly significant values that support a high diversity of frog species, large numbers of reptile taxa and significant numbers of mammals, including possums, gliders, macropods and bats. Inland wetlands were also found to be significant breeding and feeding sites for birds. Assessments of conservation value were based on flora and fauna species listed as endangered, vulnerable or rare under state or Commonwealth legislation (table 5.1).

Inland wetlands support seven endangered regional ecosystems listed under the *Vegetation Management Act 1999*, along with a further 22 regional ecosystems listed as of concern. Inland wetlands are also important in supporting a wide variety of plant and animal species, including many with significant conservation value.



Inland wetlands can be significant breeding and feeding sites for birds. (Photo: DNRM)

Table 5.1 Flora and fauna conservation values of selected wetlands within the Southeast Queensland bioregion

Wetland type	Number of wetland sites	Number of regional ecosystems listed as endangered, of concern and of no concern				Number of plant taxa listed as endangered, vulnerable or rare			Total number of plant taxa listed	Number of animal taxa listed as endangered, vulnerable or rare			Total number of animal taxa listed
		E	OC	NC	Total	E	V	R		E	V	R	
Inland	10	7	22	25	54	4	18	49	71	10	17	33	60

E = endangered
OC = of concern
NC = not of concern
V = vulnerable
R = rare

Source: Adapted from Knight 2002

Aquatic ecosystems—fish

Summary

Many factors determine the health of freshwater fish communities. They include water quality, river flows, instream habitat and quality of riparian vegetation, but these are discussed elsewhere in this chapter. Other specific factors that threaten Queensland's fish fauna include the many types of artificial barriers to fish movement common within the state's waterways, as well as exotic fish species and freshwater fishing. Barriers prevent essential free movement along waterways, both within freshwater and between freshwater and estuarine areas, and onto floodplains. Considerable progress has been made in the design and construction of many fishways to mitigate the impacts of artificial barriers to fish migration, but this program has not been resourced in recent years. Many species of exotic fish have formed significant self-maintaining populations in Queensland waters. As part of an integrated pest management strategy, prevention of new infestations and the control of spread of existing infestations have been targeted. Freshwater fishing is increasing in popularity, and so long-term monitoring programs have been established and management plans for the sustainable use of both commercial and recreational species have been developed.

Description

In Queensland, the only primary freshwater species are the lungfish (*Neoceratodus forsteri*) and the northern and southern saratogas (*Scleropages jardinii* and *Scleropages leichhardti* respectively). Many other species, for example Australian bass (*Macquaria novemaculeata*) and jungle perch (*Kuhlia rupestris*), maintain close affinities with marine environments and migrate between freshwater and estuarine reaches to spawn. In Queensland fishes occupy all freshwater habitats, from major river systems to shallow waterholes and floodplain wetlands to artesian mound springs where water temperatures may reach 46°C (Wager and Unmack 2000).



*Australian bass (*Macquaria novemaculeata*) migrate beween freshwater and estuarine reaches. (Photo: DPI)*

The fauna contains many species of recreational fishing value, as well as commercially valuable species for either commercial fisheries or the aquarium trade. Freshwater fishes are also important indicators of river health and there is a strong community perception that a healthy fish community equates to a healthy river system. The health of freshwater fishes is dependent on a number of biotic and abiotic factors. Many of these, including water quality, changes to flow regimes, changes to physical habitat and impacts on riparian vegetation, are discussed elsewhere in this chapter.

Pressures

Barriers to fish movement

Artificial barriers to fish movement are common within Queensland's waterways. They include dams, weirs, floodgates, road crossings and culverts. Free movement along waterways, both within freshwater and between freshwater and estuarine areas, and onto floodplains is an essential requirement for many freshwater fishes. Fishes move for many reasons, including completion of life cycles, to compensate for the downstream drift of pelagic eggs or larvae, or simply to optimise use of available habitat. While data are not presently available on the number and type of barriers on a statewide basis, it is clear that artificial barriers have had a significant impact on fishes inhabiting freshwaters. For example, severe declines in the abundance of barramundi (*Lates calciferi*) have occurred in the Fitzroy River due to instream barriers such as the Fitzroy Barrage (Stuart 1997). The Pioneer River has reduced species diversity in its fish community upstream of the Marian Weir (Marsden 2000). Recent data collected by the Queensland Government have indicated that there are some 2500 small potential barriers to fish migration in the lowland coastal areas of the Mackay–Whitsunday region alone (Marsden, T.J., pers. comm.).



Artificial barriers to fish movement, such as control weirs, can have an impact on fishes inhabiting freshwaters. (Photo: DNRM)

Spread of exotic fishes

Exotic species have many impacts on native fishes: they compete with native fishes for food or space, eat native fish eggs or fry, behave aggressively towards native species and cause habitat degradation. Any species that has formed a self-sustaining population has the potential to become a pest. To date, 16 species of exotic fish have formed significant self-maintaining populations in Queensland waters (Arthington et al. 1999). While some uncertainty remains about the level of threat posed by exotic species to the health of waterways, it is potentially very high. Carp (*Cyprinus carpio*), tilapia (*Tilapia mariae* and *Oreochromis mossambicus*) and gambusia (*Gambusia holbrooki*) are the species considered to be posing the greatest threat.



*Gambusia (*Gambusia holbrooki*), an exotic fish, is considered a potential threat to the health of waterways. (Photo: Queensland Museum)*

Commercial and recreational fishing

Historically, the only commercial freshwater fishery has been for eels. No commercial eel fishing occurs outside impoundments. Both the long-finned eel and short-finned eels have been targeted, although the long-finned eel makes up the majority of the catch. Eels have a long generation time and a low natural mortality once the adult stage is reached. They are thought to breed only once and then die after spawning. These characteristics make them particularly vulnerable to overfishing (Wohlsen et al. 2002).

Freshwater fishing is not as popular as saltwater fishing but is increasing in popularity, from 28.8% of anglers in 1996 to 33.2% in 2001 (Higgs and McInnes 2001). The percentage of anglers who fish rivers decreased from 48.5% in 1996 to 42.8% in 2001, and there was a significant increase in anglers targeting impoundments, up from 29.1% in 1996 to 39.2% in 2001 (Higgs and McInnes 2001). Typically, freshwater anglers do not target a particular species (57.2%); however, the species that are targeted include golden perch (15.9%), barramundi (11.0%) and Australian bass (10.3%) (Higgs and McInnes 2001).

Condition and trends

Fisheries-dependent data—commercial and recreational fishing

Declines in catch rates of adult eels in impoundments are apparently due to overfishing and lack of recruitment into these impoundments. The number of eel trappers has varied annually, peaking in 1996 (Wohlsen et al. 2002). Since then, the trapping effort per permit holder has increased while catches have declined. The adult impoundment-based eel fishery had followed a typical catch–effort pattern for a fishery starting with a large unexploited stock with little opportunity for recruitment. High catch rates were observed initially and have since decreased, despite increasing effort.

Recreational fishing trends have been assessed from diaries kept by anglers, and the results of catches from 1997 and 1999 have been compared for some key freshwater recreational fish species (Higgs 2001). There is some indication of a reduction in the catch of golden perch in the Murray–Darling region and an increase in the barramundi catch in the Wet Tropics. These data are only preliminary, however, and will need to be followed over a longer period to determine whether the apparent trends are real.

Fisheries-independent data—distribution of exotic fish species

As part of the Queensland Government's long-term freshwater monitoring program, which started in 2000, Jebreen et al. (2002) reported the distribution of native and exotic fish species in ten river systems. In general, species diversity decreased with increasing latitude, the greatest number of species occurring in the Daintree, Herbert and Johnstone rivers and the lowest number in the Warrego and the Condamine.



Carp is an exotic species considered to be detrimental to receiving ecosystems. (Photo: Queensland Museum)

Four exotic species were recorded: goldfish (*Carassius auratus*), carp, gambusia and *Tilapia mariae*. The latter three are considered to be the most detrimental to receiving ecosystems. The Condamine, Warrego, Noosa, Mary and Johnstone rivers all contained at least one of these three species. No exotic species were recorded from other rivers among the ten studied.

Apart from the Lake Eyre and Gulf drainages, most river systems have been invaded by one or more exotic fish. The range of the tilapia species *Oreochromis mossambicus* has increased since 1999. It now occurs in Tinaroo Dam on the Barron River, but was previously found only upstream of the dam. It has also been found in Boondooma Dam on the Burnett River. The infestation of Boondooma Dam must have been caused by accidental or deliberate introduction rather than natural dispersion. The occurrence of tilapia in Tinaroo Dam is of most concern as the species could enter the Mitchell River System and hence the Gulf Drainage through the Mareeba-Dimbulah irrigation system.

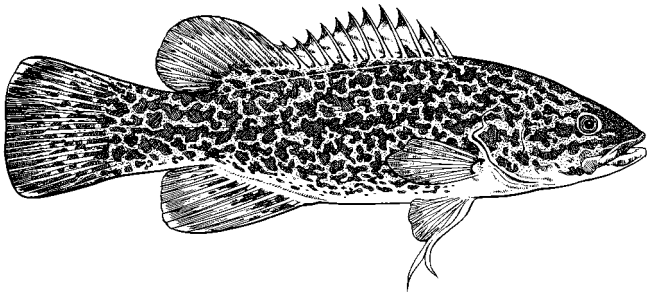


The range of tilapia has increased since 1999. (Photo: Queensland Museum)

Conservation status of freshwater fishes

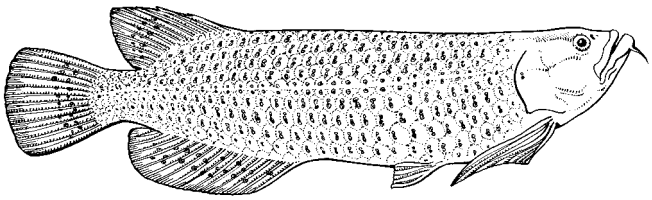
The conservation status of Queensland freshwater fishes is determined using the Conservation Status of Australian Fishes (Crook and Pogonoski, in press), compiled and reviewed annually by the Australian Society for Fish Biology (ASFB).

Six species of freshwater fishes are considered critically endangered: Elizabeth Springs goby (*Chlamydogobius micropterus*), Edgbaston goby (*Chlamydogobius squamigenus*), Bizant River shark (*Glyphis* sp. A), Mary River cod (*Maccullochella peelii mariensis*), freshwater sawfish (*Pristis microdon*) and redfinned blue eye (*Scaturiginichthys vermeilipinnis*). Oxleyan pigmy perch (*Nannoperca oxleyana*) and honey blue eye (*Pseudomugil mellis*) are classified as endangered.



The Mary River cod is among the freshwater fish considered as critically endangered. (Illustration: Paul Lennon, DPI)

A further six species are considered to be vulnerable: silver perch (*Bidyanus bidyanus*), Cairns rainbowfish (*Cairnsichthys rhombosomoides*), Darling River hardyhead (*Craterocephalus amniculus*), Bloomfield River cod (*Guyu wujalwujalensis*), freshwater whipray (*Himantura chaophyraya*) and Lake Eacham rainbowfish (*Melanotaenia eachamensis*). The Murray cod (*Maccullochella peeli peeli*), Mulgrave goby (*Glossogobius* sp. B) and saratoga (*Scleropages leichhardti*) are considered to be lower risk/near threatened.



Saratoga is considered at risk of being a threatened species. (Illustration: Paul Lennon, DPI)

The Murray cod and the Australian lungfish (*Neoceratodus forsteri*) have been accepted for listing as vulnerable under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*.

Responses

Construction and restoration of fish passages

The Queensland Government and SunWater, Queensland's main water provider, have made considerable progress in the design and construction of fishways to mitigate the impacts of artificial barriers on fish migration. A state-funded program to retrofit fishways to key structures was implemented in 1999 and this has assisted the construction of 12 new fishways. Funding for the program ceased in 2001.



The Australian lungfish (pictured) and the Murray cod were nominated in 2003 for listing under the Environment Protection and Biodiversity Conservation Act 1999. *(Photo: DPI)*

A catchment-wide approach to the provision of fish passage has been undertaken by the lower Fitzroy-Dawson catchment (Cotterell and Jackson 1999); such an approach is also being prepared for the Burnett catchment.

Integrated pest management for control of exotic fish species

Since 1999, the Queensland Government has developed a strategy for the control of exotic pest fishes. Released in 2001, *Control of Exotic Pest Fishes: An Operational Strategy for Queensland Freshwaters 2000–2005* (Mackenzie et al. 2001) emphasises the prevention of new infestations and the control of exotic species already established using the principles of integrated pest management.

Sustainable management of commercial and recreational fisheries

Sustainable management of freshwater commercial and recreational fisheries is provided under the *Fisheries (Freshwater) Management Plan 1999* and under the broader management framework provided by the *Fisheries Act 1994* and the *Fisheries Regulation 1995*. The commercial eel fishery in Queensland is managed sustainably by ensuring that a large percentage of the freshwater habitat of eels is closed to commercial fishing.

Long-term monitoring program

The Queensland Government started a long-term freshwater monitoring program in 2000. The objectives of this program are to monitor changes in key recreational and commercial fish species in freshwater river systems.



Fish ladders provide an avenue for fish and artificial barriers. (Photo: DNRM)



Weir, Balonne River (Photo: DNRM)

Case study: Fish management in the Murray–Darling

In 1998, the Queensland Government was contracted by the Murray–Darling Basin Commission to establish a database of the number of artificial barriers in the Queensland portion of the basin. The study was undertaken in collaboration with state agencies from New South Wales and Victoria, in order to establish a common database for the whole basin. The study was commissioned to enable informed management options to be developed to optimise fish movements in the Murray–Darling system by incorporating fishways on key structures or by changing the operation of water-regulating systems to provide drown-out flows. The results of this study have been used to develop the fishway component of the 2003 Native Fish Strategy for the Murray–Darling Basin.

In all, 651 barriers were identified, the majority being found in the Condamine-Culgoa and Border Rivers basins. It should be noted that the database incorporates only licensed structures and therefore does not include culvert road crossings, for example. Most barriers identified were farm dams or weirs and fixed crest dams or weirs; 55% were across creeks and 28% were across rivers. Information on the drown-out characteristics is required in order to properly assess the significance of these barriers to fish movements in the Murray–Darling; however, the number of barriers to fish movement is clearly a significant issue in the Queensland portion of the basin.

Summary of condition and trend indicators

Aquatic ecosystems—fish

NRM region/*catchment*	Indicator		
	Fisheries-dependent data—commercial and recreational fishing	Fisheries-independent data—distribution of exotic fish species	Conservation status of freshwater fishes
Cape York			2^{CE}, 1^{V}
Northern Gulf			1^{CE}, 1^{V}
Mitchell		38^{NS}	
Wet Tropics	↑ N Qld barramundi catch		2^{V}, 1^{LR}
Johnstone		49^{NS}, 1^{ES}	
Daintree		49^{NS}	
Herbert		45^{NS}	
Southern Gulf			1^{CE}
Fitzroy			1^{LR}
Burnett–Mary			1^{CE}, 2^{E}
Mary		24^{NS}, 1^{ES}	
Gregory		29^{NS}	
South East			
Logan		32^{NS}, 2^{ES}	
Noosa		24^{NS}, 1^{ES}	
South West	↓ Darling Downs golden perch catch		2^{V}
Condamine		13^{NS}, 3^{ES}	
Warrego		11^{NS}, 1^{ES}	
Desert Channels			3^{CE}

Key to trend:
↑ Increasing
↓ Decreasing
NS Native species
ES Exotic species

Key to conservation status:
CE Critically endangered
E Endangered
V Vulnerable
LR Lower risk

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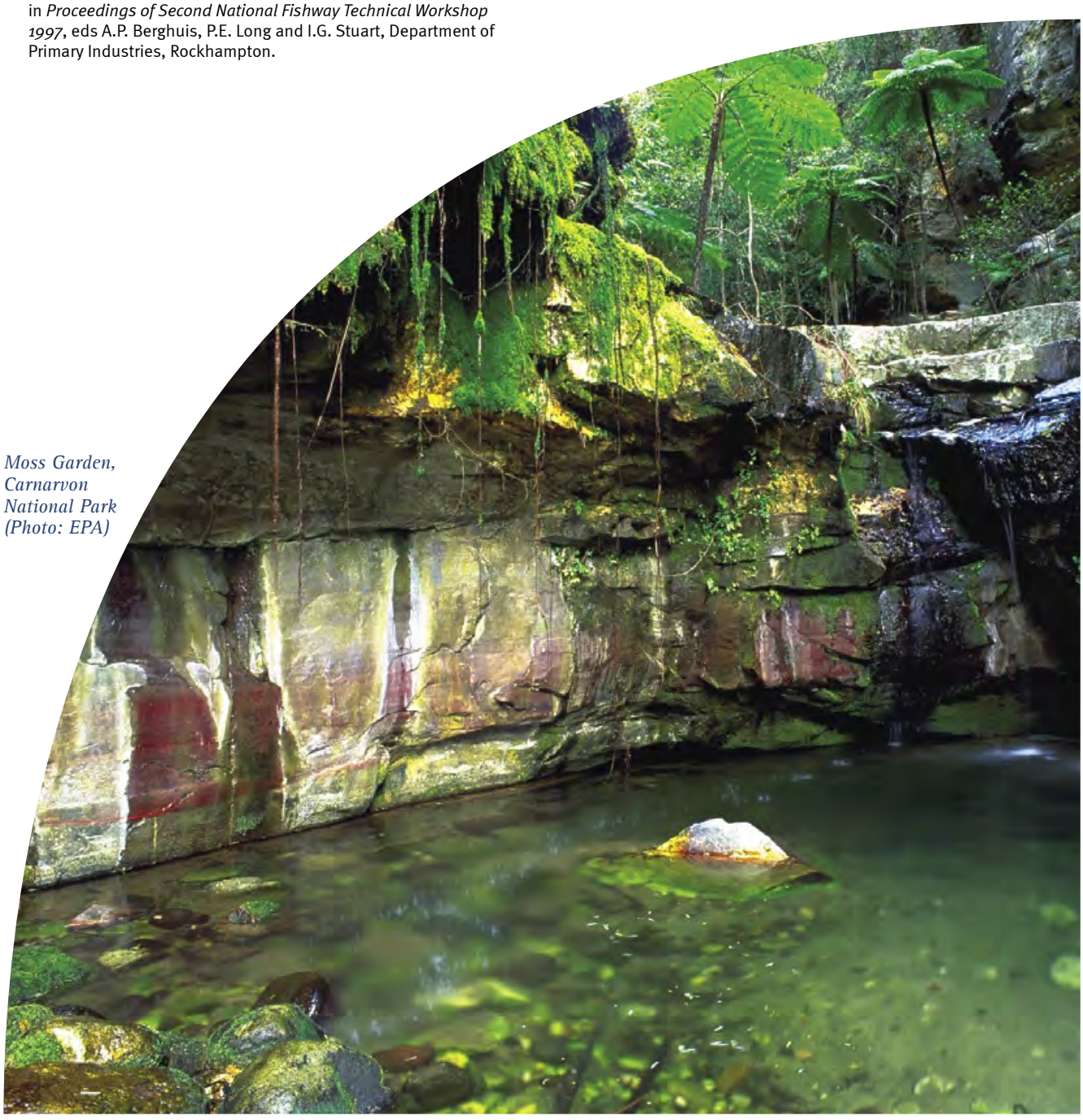
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Moss Garden, Carnarvon National Park (Photo: EPA)



Lakes Numalla and Wyara, Currawinya National Park (Photo: EPA)

6 The coastal zone

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Authors

Greg Fisk, Jonathan Hodge, Lachlan Hurse, Dr Andy Steven, Lynne Turner and Jim Waldron, Environmental Protection Agency; Brad Zeller, Department of Primary Industries

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Introduction

Queensland's coastal zone is home to around 85% of the state's population. Queenslanders and tourists are drawn to its sandy beaches, abundant native wildlife, tropical rainforests, extensive coastal wetlands and the world's largest sand island and coral reef system. The state's coastal environment has high-level habitat and biodiversity values encompassing extensive reef and mangrove ecosystems. The coastal zone also provides a cultural heritage shaped by Indigenous people and historic events and contains resources that are a natural inheritance of immense economic, cultural and intrinsic value.

Used wisely, these resources will continue to contribute to the lifestyles and livelihoods of all Australians. However, like many natural resources, they are subject to increasing pressure from rapid urbanisation and economic development. Such pressures present challenges for the sustainable use of the coastal environment.

This chapter examines four major coastal zone issues:

- coastal resource use and development;
- coastal water quality;
- coastal habitats and biodiversity; and
- coastal variability—physical processes.

Defining the coastal zone

Queensland's mainland coastline extends about 6000 km, from the Gulf of Carpentaria in the west (138°E) and Cape York in the north (10°41'S) to Point Danger in the south-east (28°10'S, 153°33'E). When the 1165 offshore islands and cays are included, the coastline's length is about 9500 km. The Great Barrier Reef consists of 3400 separate coral reefs, shoals and other formations and extends more than 2300 km from Bramble Cay in the north to Lady Elliott Island in the south.



The majority of Queenslanders live in the coastal zone. (Photo: EPA)

The area of the catchment draining to the coast from the east coast mainland is 447 655 km², and that from the Gulf of Carpentaria is 450 815 km². Individual catchments range in size from several square kilometres to 142 645 km² (the Fitzroy River catchment).

Queensland's coastal zone takes in catchment areas through to the limit of state waters (figure 6.1).

In this chapter, the coastal zone is taken to comprise those areas of land that clearly affect estuarine and marine processes and are adjacent to saline waters, and those waters that are within the zone of influence of terrestrial processes. In the quantitative assessment of spatial data within this report, the coastal zone layer has been defined as the area within 5 km of the coastline and up to 10 m above sea level (figure 6.2).

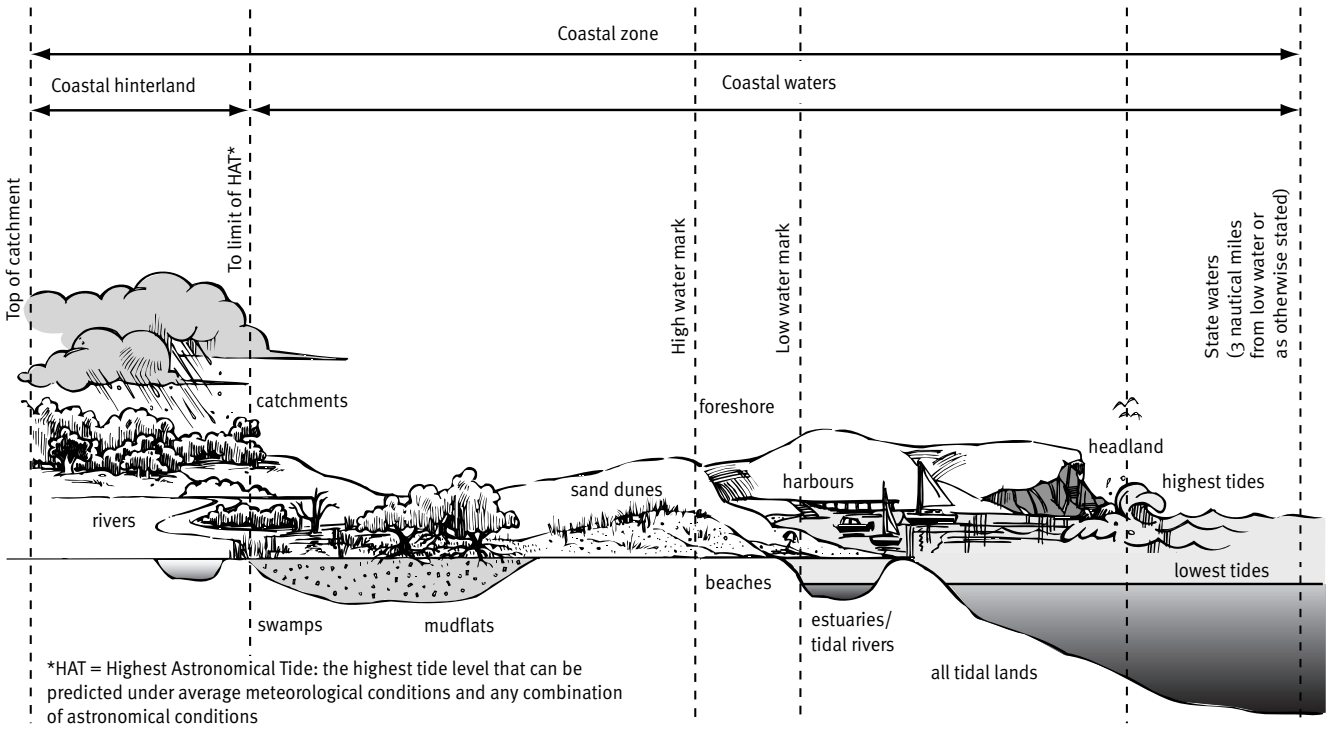


Figure 6.1 *The coastal zone*
Source: EPA

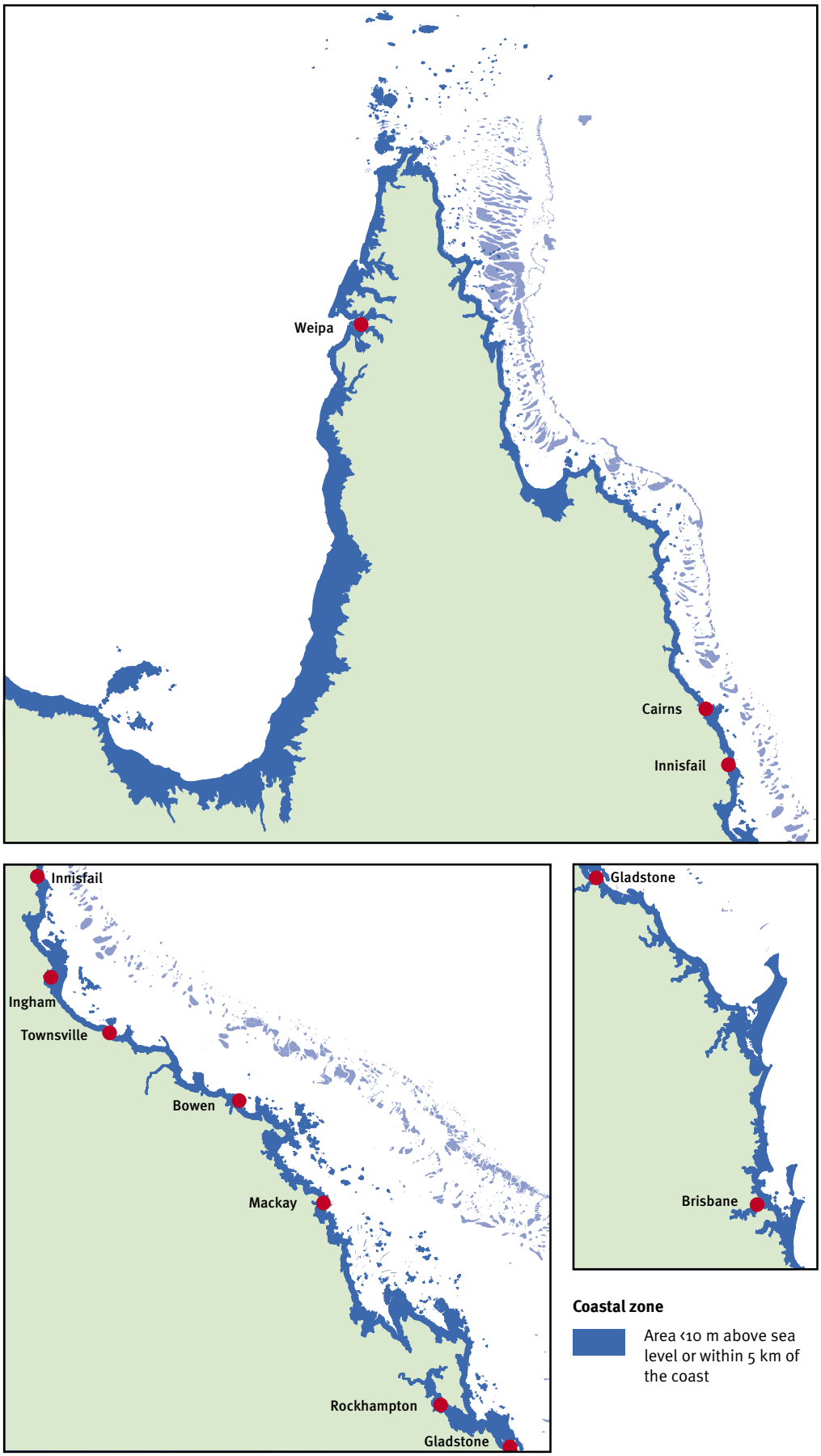


Figure 6.2 *The coastal zone as defined for data analysis within this report*
Source: EPA

Coastal resources and values

The coastal zone's vast diversity of plants, animals, landforms, habitats and ecosystems support ecological health, social wellbeing and economic interests. To manage the multiple and competing demands on coastal resources, it is useful to think of the uses, characteristics or qualities of these resources. These uses, characteristics and qualities are known collectively as 'values'.

The relationship between coastal resources and the values attributed to them is complex. Competition for the same resource can lead to conflicts in the protection and management of values. For example, beach and dune systems provide habitat for native plants and animals but are also important for their recreational value. Multiple values associated with a single resource usually result in pressures that may affect the resource's capacity to provide services.

Table 6.1 provides an overview of the coastal zone's major resources and their values, including:

- major resource types;
- social, economic and ecological values of each resource type (mostly described by landform type);
- major pressures on the values of each resource; and
- trends in the resource condition.

Estimates of coastal management pressures and trends will vary greatly by region and by coastal resource type within that region. The information and indicators presented explore pressures on coastal systems and their current condition, and the effectiveness of the various responses.



Marine infrastructure and urban development are environmental pressures on the coastal zone. (Photo: EPA)



Catchments draining to the coast are included in the coastal zone. (Photo: EPA)

Issues and indicators

To report effectively on coastal resources, it is necessary to have appropriate indicators that can provide a measure of their condition and the effectiveness of responses to pressures over time.

As table 6.1 shows, many of the key issues within the coastal zone are associated with managing development pressures that continue to alter natural systems and processes. Urban expansion and property booms, agricultural expansion and intensification, and marine and land infrastructure development for transport and waste disposal are sources of considerable environmental pressure. The challenge is to manage land and coastal resource use in a sustainable manner to protect the internationally and nationally significant ecological, economic, cultural and social values of Queensland's coastal zone.

This chapter examines available data to report on environmental conditions, pressures and responses within the coastal zone.

Reporting on the state of Queensland's coastal zone means examining complex natural ecosystems and processes, and the ways that human activities influence them. It also involves evaluating the sustainability of human activities that affect natural systems and the effectiveness of management responses. Data are not available to report on all coastal resources and their values, and existing data are not always sufficient to allow detailed conclusions about the condition of particular resources or the trends in their condition.

This chapter provides updated information in relation to the indicators established in 1999 (EPA 1999a). Further refinement and improvement of coastal indicators are required.

Table 6.1 An overview of coastal values, resource types, resource trends and pressures on coastal values

Coastal values	Resource type									
	Beach and dune systems	Coastal wetlands	Coastal forests, heathlands	Headlands	Rocky foreshore	Coral reef systems	Soft-bottom (benthic) systems	Mid-water column (pelagic) systems	Coastal and estuarine waters	Sandy-bottom systems
Habitat for native plants and/or animals	1,2,3,4,6,7	1,2,3,4,6,8,10	1,3,4,6	3,4,6	1,4,5,6	1,2,4,5,6,8	1,2,3,6,7	5,6,8	1,2,3,4,5,6,8	2,5,6,7,8
Habitat for migratory birds	1,3,4,6	1,2,3,4,8,10	4	3	1,4,6				6,8	
Nursery habitat	1,3,4,7	1,2,3,4,8,10		3			1,2,3,6,7			8
Biological diversity		1,2,3,6,8,10	2,3,4		1,4,5,6,8	1,2,4,5,6,8	1,2,3,7			
Biological productivity		1,2,3,4,8	1,3,4,10				1,3,6,7	1,5,8	2,8	5,8
Fisheries/collecting		1,2,3,4,6,8,10			1,4,5,6,8,10	1,4,5,6,8,10	3,6,10	5,8,10	2,5,8,10	5,8,10
Biotechnology		1,2,3,4,5,8,9, 10			1,4,5,6,8	1,4,5,6,8				
Indigenous Traditional Owner values	1,3,4,6,7,10	1,2,3,4,6,8,10	3,4,6,10	3,4,6	1,4,5,6	1,4,5,6		5	5,8	
Coastal-dependent development	1,3,6,8,9	1,3,8,9			9	1,6,9	8,9		1,9	9
Tourism	1,3,4,8,9	1,3,4,5,9	3,4,9	3,9		1,4,9		5	3	
Sand and gravel extraction	1,3,9	3,8,9		3,9						9
Shore and sediment stabilisation	1,4,6,7	1,2,4,9	1,4							
Dissipative barrier to erosive forces	1,4,6,7	1,4			1,7	1,5				
Water quality		1,2,4,8				1,2,4,6,8			2,4,8	
Cultural heritage	1,3,4,6	1,2,4,6,10	3,6	3,6	1,5,6	1,4,5,6			5,6	
Coastal-dependent primary production		1,3,4,6,8,9	3,9		5,8	1,4,5,5,8			4,6,8	
Scenic amenity	1,3,4,6	1,2,3,4,6,8	3,4	3,6,7	3,7	1,4,6				
Recreational amenity	1,3,4,7	1,2,3,4,6,8	3,4	3,9	5,9	1,4,6	2,3,6,10	5,6,8,9,10	6,8,9,10	5,8,10

Key to pressures:

No.	Primary pressure	Secondary pressure
1	Climate change impacts, climate variability and sea level rise	Ocean warming, biological pressures
2	Hydrological changes	Water extraction and allocation, dams/weirs/barriers, catchment runoff, control of biting insects
3	Urban development	Land reclamation, inappropriate infrastructure, population growth, tourist facilities, effluent release
4	Habitat loss and degradation	Land clearing, marine incidents, erosion, invasive pests and weeds, introduced marine species, threatened species
5	Harvesting	Fishing intensity, collecting selectivity and intensity
6	Access impacts	Tourism and recreational activities, anchoring, shipping, trawling, boat strike
7	Extraction	Sandmining, dredging
8	Contamination and pollution	Acid sulfate soil disturbance, sediment deposition and rubbish dumping, point and diffuse source inputs, nitrification, algal blooms
9	Use restrictions	Storm and flood effects, coastal processes, coastal landscapes, nursery habitat, migratory bird habitat and Indigenous Traditional Owner significance
10	Insufficient knowledge of process change	Limited records, lack of respect, limited understanding

Key to trend:
Trend in condition of value

= Improving
= Little change or no statewide trend
= Declining

Responses in coastal management since 1999

Significant advances have been made in the development of coastal and marine policy and legislation since 1999. This section summarises the state's progress towards more coordinated coastal management since 1999, particularly in terms of:

- partnerships among governments, communities and industries working to achieve effective use and management of Queensland's coastal zone;
- policy and legislation to provide better coastal protection;
- Indigenous involvement in coastal management; and
- research and education.

Partnerships

A number of important partnerships in coastal management operated throughout Queensland during the period 1999–2003.

The national Coastcare program involved funding of $4.3 million over seven years by the Commonwealth Government, under the Natural Heritage Trust, and the Queensland Government. Coastcare encouraged community organisations to become involved in coastal management, principally through on-ground activities. Coastcare facilitated significant projects to improve coastal management through projects related to dune management and coastal revegetation projects.

The Coasts and Clean Seas program involved Commonwealth funding of $4.2 million over five years under the Natural Heritage Trust. Several important coastal management projects carried out by local government, state agencies, industry and community organisations were funded under the Coast and Clean Seas banner, contributing to the conservation, sustainable use and repair of coastal and marine environments.

The Queensland Government's Coastal Acquisition Fund involved funding of more than $8.5 million over four years to purchase land considered too sensitive for development or to preserve public access to the coast. A significant feature of the Coastal Acquisition Fund was cooperation with local government in achieving beneficial coastal management outcomes. Commonwealth funding was also obtained under the National Reserve System program. In many cases, the Coastal Acquisition Fund has fostered closer relationships between state and local governments to work cooperatively towards achieving valuable coastal management outcomes for the community.

At the regional scale, partnerships help to deliver specific coastal management strategies such as the Gladstone Harbour Protection and Enhancement Strategy, a variety of plans such as integrated catchment management plans, industry codes of practice, and various works and activities that involve industry and the community in projects that help manage coastal areas. The Moreton Bay Waterways and Catchments Partnership is a south-east Queensland initiative that provides a model for Australia on how more than 60 community, government, recreation, business, industry, Traditional Owners and research representatives can work together to achieve effective coastal and water quality management outcomes.

Policy and legislation

The management of the coastal zone is complicated by overlapping and adjoining boundaries between many government agencies, legislation and plans (figure 6.3).

International

The Commonwealth Government is a signatory to international treaties and conventions that involve protecting, conserving or managing coastal resources (table 6.2). These treaties and conventions continue to be enhanced and expanded; under Australia's constitution, all tiers of government are obliged to work within the agreed framework. These conventions directly influence Queensland's coastal zone management. (See also 'Coastal habitats and biodiversity', page 6.44, and Chapter 9, 'Natural and cultural heritage'.)

Table 6.2 International treaties that affect Queensland's coastal zone

United Nations Convention on the Law of the Sea (1982)	Convention recognises security of Australian access to natural resources in its exclusive economic zone combined with the obligation to prevent marine pollution and preserve the marine environment.
Ramsar Convention	Convention on Wetlands of International Importance Especially as Waterfowl Habitat provides the framework for intergovernmental cooperation in the protection and sustainable use of wetlands.
CAMBA	Agreement between the Government of Australia and the Government of the People's Republic of China for the Protection of Migratory Birds in Danger of Extinction and Their Environment. It lists 81 species of migratory birds.
JAMBA	Agreement between the Government of Australia and the Government of Japan for the Protection of Migratory Birds and Birds in Danger of Extinction and Their Environment. Similar commitments to CAMBA.
World Heritage Convention	Convention Concerning the Protection of the World Cultural and Natural Heritage
CITES	Convention on International Trade in Endangered Species of Wild Fauna and Flora. Species identified as endangered are listed under the *Environment Protection and Biodiversity Conservation Act 1999* (Cwlth).
United Nations Convention on Biological Diversity	Convention seeks to conserve biological diversity, the sustainable use of its components, and fair and equitable sharing of benefits arising from using genetic resources.
London Sea Dumping Convention	Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter
MARPOL	International Convention for the Prevention of Pollution by Oil from Ships

Source: EPA

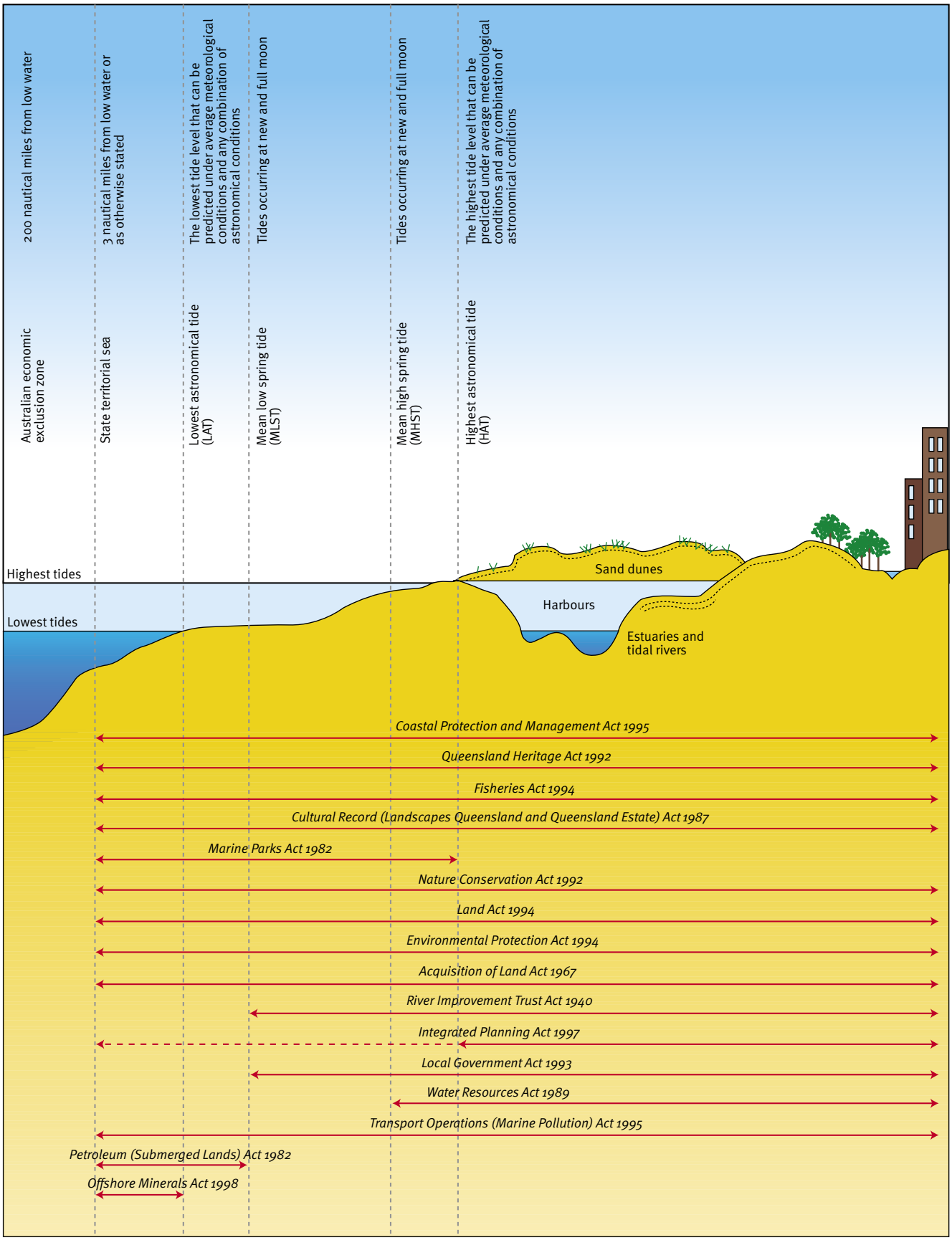


Figure 6.3 *Key Queensland legislation and jurisdiction over the coastal zone. Management and administration of tidal lands and marine waters rest with three levels of government. Many Commonwealth and Queensland Acts influence the way in which coastal resources are managed and development in the coastal zone.*

Federal

Coastal management is increasingly being placed within an overarching national context. Australia's Oceans Policy (EA 1998) provides a strategic national framework for the planning, management and ecologically sustainable development of fisheries, shipping, petroleum, gas and seabed resources while ensuring the conservation of the marine environment.

The Commonwealth Government's role in development assessment has increased significantly since the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) came into force in July 2000. Under this Act the Commonwealth Government assesses development projects with the potential to affect areas of national environmental significance including coastal World Heritage Areas and places designated by international conventions, such as the Ramsar convention (see Chapter 9, 'Natural and cultural heritage').

The Commonwealth also has input into coastal protection by matching funding from other sources for a range of initiatives in the areas of natural resource management and water reform, as well as in the long-established area of marine park management. Projects under the second round of the Natural Heritage Trust (NHT2), starting in 2002–03 and scheduled to run until 2006–07, also relate to coastal management.

State

The Environmental Protection Agency (EPA) administers Queensland's suite of coastal legislation, which includes the *Coastal Protection and Management Act 1995* (Coastal Act). The *Beach Protection Act 1968*, the *Canals Act 1958* and the *Harbours Act 1955* were repealed on 22 October 2003. Coastal management under these statutes involved the preparation and coordination of whole-of-government coastal management plans, the assessment and permitting of coastal development, and the establishment of key coastal management advisory bodies at the state and regional levels.

In addition to the Coastal Act, a range of equally important legislation deals with particular aspects or areas of the coastal zone (table 6.3).

Table 6.3 Other significant legislation relevant to the coastal zone

Marine parks	The EPA, through the Queensland Parks and Wildlife Service, administers the *Marine Parks Act 1982*. The Act provides for the declaration of multiple use marine parks in state waters, the preparation of statutory zoning plans that regulate entry and use in a marine park, and the preparation of management plans for specific issues in marine parks.
State land, water and vegetation	The Department of Natural Resources and Mines regulates the use of state land and waters through the *Land Act 1994* and the *Water Act 2000* and native vegetation on freehold land under the *Vegetation Management Act 1999*.
Fisheries	The Department of Primary Industries through Queensland Fisheries Service administers the *Fisheries Act 1994*, which provides for the preparation of fisheries management plans, the declaration of fish habitat areas, the regulation of certain development activities such as aquaculture and the regulation of commercial and recreational fishing practices.
Ports, transport infrastructure and marine pollution	Queensland Transport administers the *Transport Infrastructure Act 1994*, which provides for the preparation of transport infrastructure strategies and establishes the powers and responsibilities of Queensland port authorities. Queensland Transport also administers the *Transport Operations (Marine Pollution) Act 1995*, which provides for the preparation of strategies for vessel-sourced marine pollution.



Local governments undertake treatment of sewage and wastewater before it is released into waterways. (Photo: EPA)

Local

Local governments play a critical role in coastal planning and management in Queensland. By preparing planning schemes under the *Integrated Planning Act 1997* (IP Act), local government regulates land use and development for the local government area. State interests must be taken into account in the preparation or review of local government planning schemes or otherwise considered in the assessment of development in the coastal zone. These interests include the State Coastal Plan and other state planning policies such as *SPP 2/02: Planning and Managing Development Involving Acid Sulfate Soils* and *SPP 1/03: Mitigating the Adverse Impacts of Flood, Bushfire and Landslide.*

Local governments also undertake:

- funding, construction and management of coastal management infrastructure;
- acquisition and management of coastal lands to protect coastal resources;
- management of waterways in the coastal zone;
- funding, construction and management of water quality infrastructure;
- cleaning and maintenance of foreshores and waterways; and
- management of public access to the coast.



Local governments manage public access to the coast. (Photo: EPA)

Under the Local Government Bodies' Capital Works Subsidy Scheme, the state government pays a standard percentage rate of subsidy on the capital cost of a range of works relevant to local governments' management of the coastal zone. These include:

- sewage treatment works and upgrades of existing facilities;
- reuse of wastewater as an alternative to discharging it into waterways;
- tourist facilities including beach access and facilities; and
- works to prevent erosion on beaches and foreshores and in the beds and banks of rivers and streams.

New policy and legislative initiatives since 1999

In recognition of the complexity of management arrangements operating in the coastal zone, several major initiatives have been implemented since 1999. These are directed towards achieving a broader strategic approach to the planning and management of the coast.

Major initiatives include:

- the 2002 commencement of the State Coastal Management Plan—Queensland's Coastal Policy, which seeks to provide ways to protect and manage Queensland's coastal resources as identified in 1999;
- the release of three draft regional coastal management plans, supported by the state's Coastal Protection Advisory Council and regional consultative groups;
- the introduction of significant amendments to the Coastal Act to consolidate and improve the effectiveness of the state's coastal regulatory powers; and
- agreement through a Memorandum of Understanding between the Queensland and Commonwealth governments for the development of a Reef Water Quality Protection Plan.

Implementing and improving coordination through these and other initiatives will be critical to halting and eventually reversing the pattern of coastal resource degradation in Queensland in a way that maintains the coastal zone's economic, social and environmental values.

State Coastal Plan

The State Coastal Management Plan—Queensland's Coastal Policy (State Coastal Plan) commenced in February 2002 and represents a 'whole-of-government' approach to the management of the coastal zone. It provides statewide direction to decision makers, land managers and the community on coastal management issues (figure 6.4). It deals with ten topic areas: coastal use and development, physical coastal processes, public access to the coast, water quality, Indigenous Traditional Owner cultural resources, cultural heritage, coastal landscapes, conserving nature, coordinated management, and research and information.

The State Coastal Plan has the effect of a state planning policy under the IP Act. Local governments must reflect the State Coastal Plan in the preparation of new IP Act planning schemes and assessment of development applications. Indigenous Traditional Owners, community groups, local government, catchment and Landcare groups, and industry bodies also have a role in the plan's implementation.

Key initiatives contained within the plan include:

- the identification of areas of state significance for coastal management;
- strong support for protecting coastal wetlands, landscape values and public access to the coast;
- strong performance criteria and a requirement for justification for new canals, reclamation and development in erosion prone areas;
- management of state land on the coast to achieve coastal management outcomes;
- recognition of Indigenous Traditional Owners; and
- planning to adapt to climate change and sea level rise.

Coastal Protection Advisory Council

The Coastal Act established the Coastal Protection Advisory Council (CPAC) to advise the Minister for Environment on matters relating to the coastal zone and its management. It consists of one state government representative and 11 other members from local government, universities, industry, and Indigenous bodies.

The primary focus for CPAC consultation in the period 1999–2002 has been reviewing the State Coastal Plan and its public submissions. CPAC members have also worked closely with four Regional Consultative Groups engaged in the preparation of draft regional coastal plans to ensure consistency with the State Coastal Plan.

Regional coastal plans

The Coastal Act and the State Coastal Plan require the preparation of regional coastal management plans (regional coastal plans).

Regional coastal plans provide policy direction to assist the implementation of the State Coastal Plan (figure 6.5). In conjunction with the State Coastal Plan, they will identify regionally specific natural, cultural, social and economic resources, associated management issues and appropriate solutions. Regional coastal plans will also identify 'coastal management districts' where the EPA, as the Queensland Government's lead agency for coastal management, will be involved in decision making for certain types of development. Like the State Coastal Plan, regional coastal plans will be statutory instruments and will have the effect of a state planning policy under the IP Act.

Regional consultative groups representing the views of a broad cross-section of the community have been established to help develop regional coastal plans. In 2003, regional coastal plans were prepared for the Curtis Coast, Cardwell–Hinchinbrook Coast, Wet Tropical Coast and South-east Queensland Coast.

Table 6.4 shows the links between the State Coastal Plan's ten topic areas and the issues covered in this report.

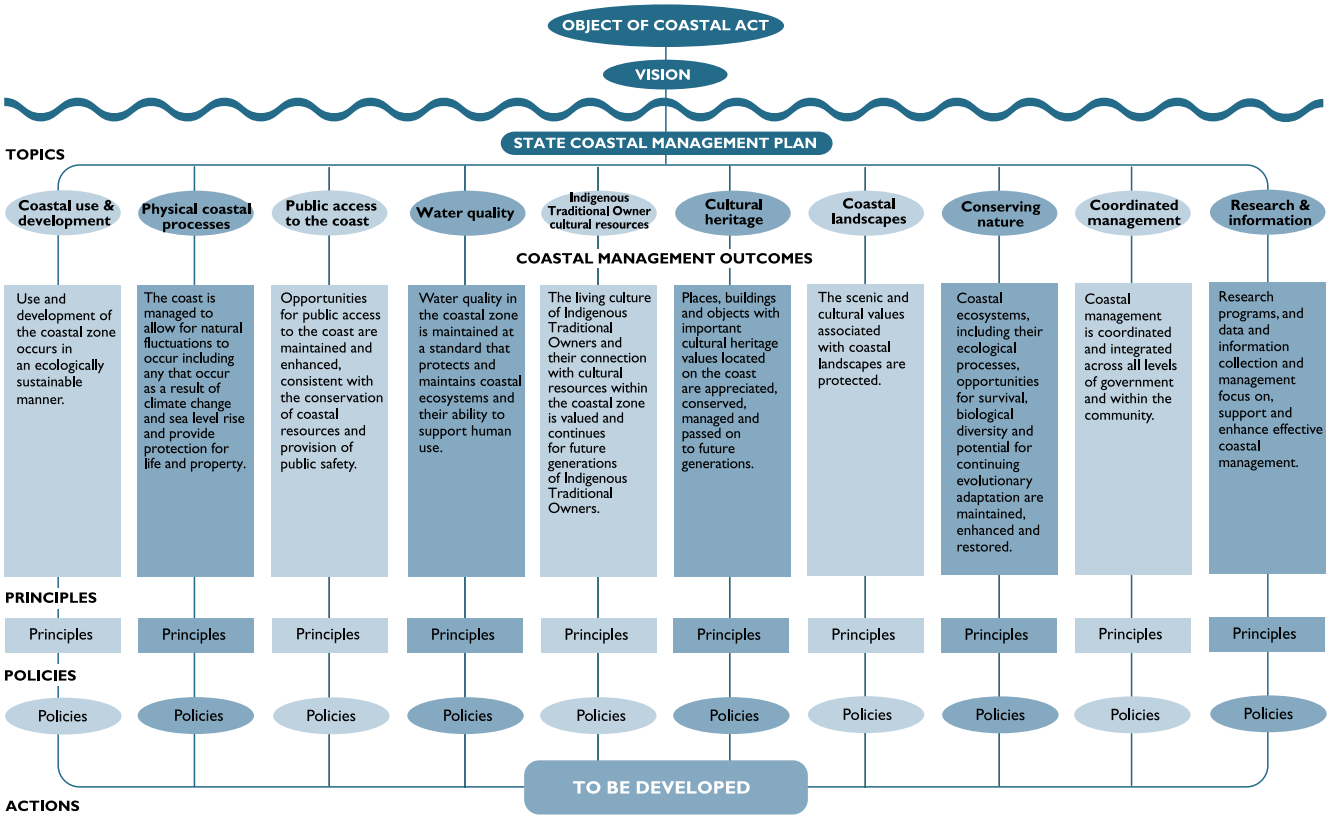


Figure 6.4 *Policy framework for managing the coastal zone*
Source: State Coastal Plan

Table 6.4 Links between the State Coastal Plan and the state of the environment report

State Coastal Plan topic areas	Coverage in this report
Coastal use and development	Chapter 6, 'The coastal zone' (Coastal resource use and development) Chapter 8, 'Human settlements'
Physical coastal processes	Chapter 6 (Coastal variability—physical processes)
Public access to the coast	Chapter 6 (Coastal resource use and development)
Water quality	Chapter 6 (Coastal water quality) Chapter 5, 'Inland waters'
Indigenous Traditional Owner cultural resources	Chapter 9, 'Natural and cultural heritage'
Cultural heritage	Chapter 9, 'Natural and cultural heritage'
Coastal landscapes	Chapter 6 (Coastal resource use and development)
Conserving nature	Chapter 6 (Coastal habitats and biodiversity) Chapter 7, 'Biodiversity'
Coordinated management	Chapter 6 (Introduction)
Research and information	Chapter 6 (all sections)

Source: State Coastal Plan



Figure 6.5 *State and regional coastal plans*
Source: EPA

Indigenous involvement in coastal management

Indigenous Traditional Owners have custodial responsibilities, traditional obligations and proprietary interests and rights in relation to the management of the coastal zone. Their involvement in the management of traditional land ranges from regular day-to-day community land management through to collaboration with state and local government authorities. Aboriginal working groups and advisory bodies have informed the development of regional coastal management plans through the involvement of Indigenous Traditional Owner groups.

An example of Indigenous participation in the management of coastal areas involves the Wuthathi people who are Traditional Owners of the Shelburne Bay area in Cape York. Using funds from the Natural Heritage Trust, the Wuthathi Land Trust has overseen the drafting of a Land and Sea Management Framework that aims to protect, maintain and integrate the cultural and conservation values of the area. The framework includes three programs: Traditional Management and Policy Development, Day-to-day Management and Community Development. It includes performance monitoring and research and development components, and envisages partnership programs to help achieve its aims (Tropical Savannas CRC 2003).

Another example of Indigenous management of coastal resources has resulted from research into the declining catch of the black jewfish (*Protonibea diacanthus*) at the northern tip of Cape York. Traditional Owners and the Injinoo community, in partnership with the Balkanu Cape York Development Corporation, the Department of Primary Industries, the Fisheries Research and Development Corporation and James Cook University, have investigated the decline with the aim of ensuring that the black jewfish fishery in northern Cape York is sustainable. The research program showed that in 1999 the number of days with peak catches were diminishing, and the specimens caught were generally smaller than those taken in the 1980s, most being immature (two to three years old). With this knowledge, charter operators, the five affected mainland communities and the Torres Shire Council agreed to a two-year closure of the fishery. Stakeholder groups have developed management options based on practical mechanisms to meet Traditional Owner and community needs (FRDC 2003).

Research and education

Comprehensive knowledge of the coastal zone resulting from research programs is an essential component of effective management programs. Greater coordination of research into Queensland's coastal zone has been achieved through the Commonwealth Government's Cooperative Research Centre Program, which has brought together a range of institutions to develop research programs more closely aligned with desired management outcomes (table 6.5). Five Cooperative Research Centres carry out research relevant to Queensland's coastal zone. The outcomes of their programs are described in later sections of this chapter.



Vrilya Point, on Cape York, is a culturally and historically important part of the coastal zone. (Photo: L. Knight, EPA)

Table 6.5 Cooperative Research Centres with research programs in the coastal zone

Cooperative Research Centre	Partners	Started	Funded until
Cooperative Research Centre for the Great Barrier Reef World Heritage Area (incorporated as CRC Reef Research Centre Ltd)	Association of Marine Park Tourism Operators Australian Institute of Marine Science Department of Primary Industries (Qld) Great Barrier Reef Marine Park Authority Great Barrier Reef Research Foundation Queensland Seafood Industry Association Inc. SUNFISH Queensland Inc.	1 July 1999	2006
Cooperative Research Centre for Coastal Zone, Estuary and Waterway Management	Brisbane City Council Central Queensland University CSIRO Curtin University of Technology Department of Natural Resources and Mines (Qld) Department of Primary Industries (Qld) Environmental Protection Agency (Qld) Geosciences Australia Griffith University James Cook University The Defence Science and Technology Organisation The University of Queensland The University of Western Australia	1 July 1999	2006
Cooperative Research Centre for Sustainable Tourism	Australian Federation of Travel Agents Ltd Canberra Tourism and Events Corp. City of Melbourne Edith Cowan University Griffith University James Cook University La Trobe University Murdoch University Tourism Council Northern Territory University NSW Parks and Wildlife Service Southern Cross University The University of Queensland Tourism Council Australia Ltd Tourism NSW Tourism Queensland Tourism Tasmania Tourism Victoria University of Canberra University of New South Wales University of Tasmania University of Technology, Sydney Victoria University Western Australian Tourism Commission	1 July 1997	2004
Cooperative Research Centre for Tropical Rainforest Ecology and Management	Aboriginal and Torres Strait Islander Commission Alliance for Sustainable Tourism CSIRO, Tropical Forest Research Centre Department of Natural Resources and Mines (Qld) Department of Primary Industries (Qld) Environmental Protection Agency (Qld) Griffith University James Cook University Queensland Parks and Wildlife Service Queensland Tourism Industry Council The University of Queensland Wet Tropics Management Authority	1 July 1999	2006
Cooperative Research Centre for Catchment Hydrology	Brisbane City Council Bureau of Meteorology CSIRO, Land and Water Department of Natural Resources and Environment (Vic.) Department of Natural Resources and Mines (Qld) Goulburn-Murray Water Authority Griffith University Melbourne Water Monash University Murray–Darling Basin Commission NSW Department of Land and Water Conservation Southern Rural Water The University of Melbourne Wimmera Mallee Water	1 July 1999	2006

Sources: Commonwealth Department of Education, Science and Training; CRCs

Summary

In 1999, the need for a more coordinated approach to coastal zone management was identified (EPA 1999a). In addition to the continuing implementation of existing legislation, several major coastal management initiatives, such as the State Coastal Plan, have been finalised or implemented. Despite these continued efforts to improve coastal management responses, coastal zone condition is not improving significantly and continues to decline against a number of criteria. From 2003, with a more coordinated coastal management framework now in place, the critical issue for Queensland will be the implementation of recent coastal management initiatives to halt declines or improve coastal resource condition.

Coastal resource use and development

Summary

Increasing coastal population and associated land use changes are among the most important factors influencing the severity of pressure on coastal resources. Population growth has increased the demand for coastal development and use of coastal resources for other human activities. Urban expansion and property booms, new tourist facilities, agricultural expansion and intensification, marine and land infrastructure for transport and waste disposal, and commercial industries contribute to economic growth in Queensland. However, the cumulative impact of these activities places severe stresses on coastal biodiversity and threatens the ability of the coastal zone to continue to support Queenslanders' wellbeing. The continuous degradation resulting from unsustainable practices poses a large management challenge.

The challenge is to achieve ecologically sustainable development in the coastal zone through initiatives that aim to conserve, manage and restore the resources and values that make the coastal zone so popular. In a climate of escalating property values, speculative purchases and expanding coastal settlements, regulation through land use planning is one means of controlling the pressures associated with population growth. The introduction of the State Coastal Plan and the preparation of four regional coastal management plans provide the basis for integrated coastal zone management by defining criteria for new development and formulating a set of planning targets and techniques aimed at sustainable coastal development.

Description

Queensland's coastal resources are finite. Its beaches and coastal and marine national parks attract millions of visitors each year and generate significant economic benefits for regions. More than 5000 ships visit Queensland ports each year, moving more than 180 million tonnes of cargo and 130 million tonnes of petroleum products through eight port authority areas and numerous smaller port facilities. In 2000–01, the asset base of all port authorities was $2.7 billion and exports were valued at $17 billion.



Queensland's eight port authorities ship a mix of cargo and petroleum products for export. (Photo: L. Knight, EPA)

The pressures on the coastal zone's ability to sustain increased use and development are associated with the basic demands of a growing population for shelter, food, health and wellbeing, transport, and financial security.

Queensland has had the fastest population growth of all Australian states and territories since the 1996 Census, increasing by 1.6% a year; the growth rate for Australia in this period was 1.2%.

The ten local government areas (LGAs) with the largest growth between 1991 and 2001 were located on the coast or around tidal rivers. The average annual growth rate for these coastal LGAs was 3.37%, more than double the average annual growth rate for the state. Between 1991 and 2001, the population of Queensland's 42 coastal LGAs grew by 780 000. This growth was strongest in south-east Queensland (table 6.6), which absorbed 80% of the state's new arrivals.

Table 6.6 Population growth in the ten fastest growing LGAs in Queensland, 1991–2001

LGA	Average annual increase	
	Persons	Percentage
Gold Coast	14 018	3.9
Brisbane	12 968	1.6
Maroochy	4 499	4.4
Caboolture	4 421	4.8
Redland	3 391	3.6
Pine Rivers	3 134	3.1
Cairns	2 906	2.5
Caloundra	2 183	3.5
Logan	2 161	1.4
Noosa	1 794	4.9

Source: ABS

With significant growth projected for the majority of coastal areas, urban development and human activity present major challenges. Conversion of land from a natural state to a developed state is one of the most significant pressures on coastal habitats and biodiversity. Whether this change is the result of a new tourist resort, the dredging of a marina, a rural subdivision or agricultural expansion, it inevitably involves modifying the natural biophysical setting.

The major activities that rely on the use of coastal resources are:

- urban development;
- tourism and recreation;
- maritime industry (ports and works);
- resource extraction;
- fishing, hunting and collecting; and
- aquaculture.

Major activities

Urban development

Coastal strip development is placing increasing pressure on coastal habitats. Figure 6.6 illustrates the changing coastal landscape in the period 1991–2001 in four key areas of rising population: south-east Queensland, the Fraser Island coast, the Townsville coast and the Cairns coast. Within these areas, development tends to occur in linear corridors or strips along coastal or riverine areas.

Clearing for urban development has been extensive along the south-east coast. Catterall et al. (1996) reported that, by 1987, 173 568 ha (71.5%) of coastal lowlands in south-east Queensland had been cleared. Between 1987 and 1994, a further 6754 ha was cleared. Most land with development potential that was not protected in the reserve estate has been cleared. Remaining native vegetation tends to be restricted to the steeper slopes of the hinterland, although such areas continue to be cleared. Clearing for development in more urbanised areas such as the south-east coast has been less intensive, but continues to have an impact on coastal resources.

Marine works such as extractive industries, dredging, reclamation and boating infrastructure (marinas, boat harbours, jetties and pontoons) generally accompany building and subdivision on the coast. These coastal-dependent land uses provide economic and social benefits to the community but also have cumulative impacts on coastal resources and their values.



Urban development continues to increase along the Queensland coastline, as seen here near Rockhampton. (Photo: J. Abbott, DLGP)

Loss of public access to the coast is another pressure associated with development in the coastal zone.

Detailed data relating to land use change are available for only selected areas.

Table 6.7 provides a summary of the state framework of legislative responses to pressures from land use change and infrastructure development.



Boating infrastructure such as marinas, boat harbours, jetties and pontoons is present at some coastal developments, providing benefits for the community but adding to the pressures on coastal resources. (Photo: EPA)

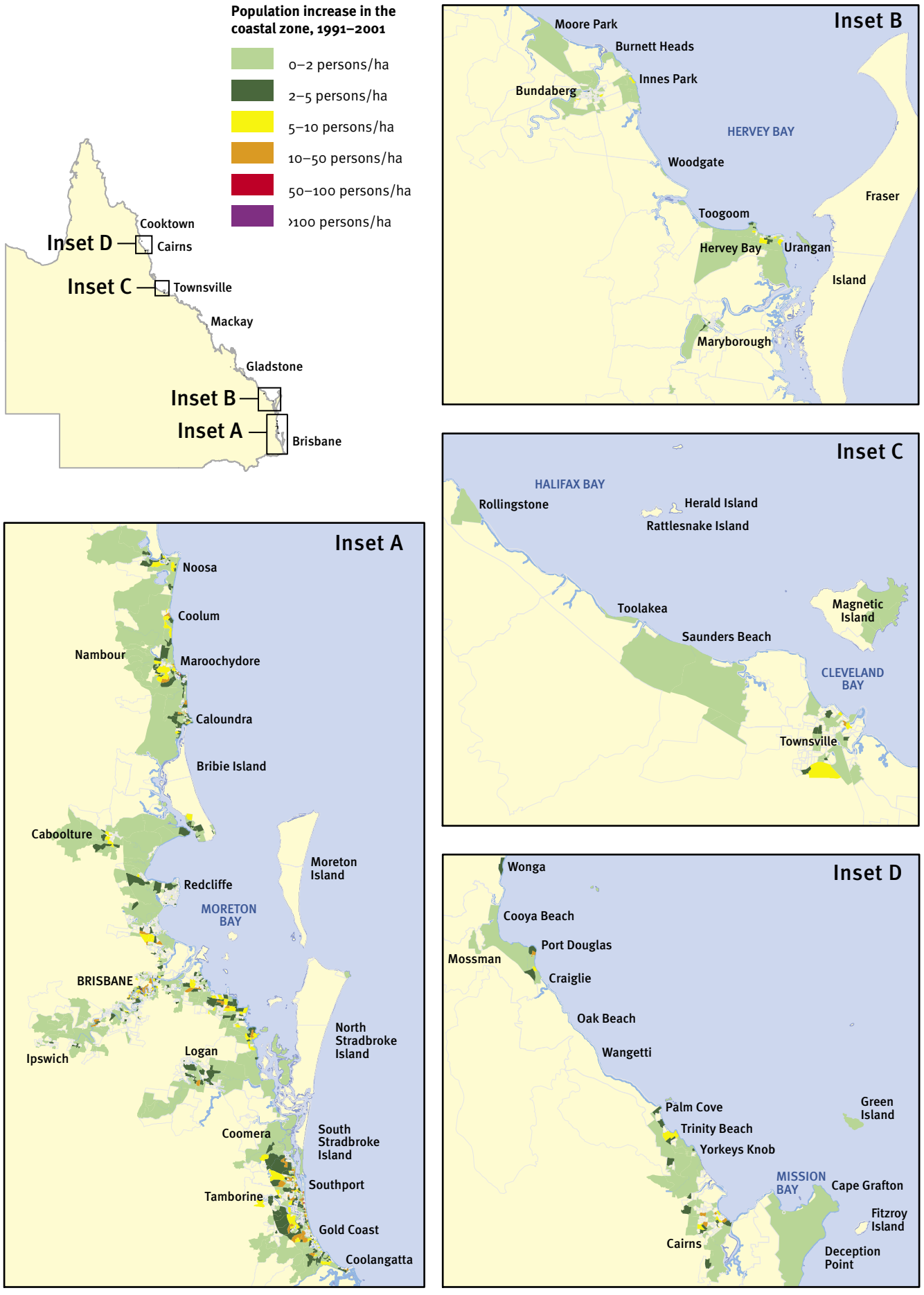


Figure 6.6 *Coastal population pressure on the environment (Sources: EPA; ABS)*

Table 6.7 Legislative responses to pressures from land use change and infrastructure development

Pressures	Response mechanism	Legislation
Land use change and other development classed as a material change of use	Integrated development assessment system (IDAS)	*Integrated Planning Act 1997*
Removal of marine plants Construction of fishways Destruction of fish habitat Aquaculture development	Permits Declaration of fish habitat areas Environmental authorities and development permits	*Fisheries Act 1994* *Environmental Protection Act 1994*
Leasehold land management—land allocation, opening/closing a road, granting easements, renewal/expiry of lease, conversion of tenure, taking up occupation, tree clearing	Leases and permits	*Land Act 1994*
Regional vegetation management Tree clearing on private land	Statutory management plans Guidelines Permits	*Vegetation Management Act 1999*
Water for consumptive use—town supplies, irrigation and riparian access to water Removal of vegetation or fill from a watercourse Removal of quarry material from a watercourse	Water resource plans, resource operations plans Water allocations or licences Approvals and permits	*Water Act 2000*
Works, reclamation and dredging on tidal land or water	Sanctions, authorities and approvals	*Coastal Protection and Management Act 1995**
Canals	Approvals	*Coastal Protection and Management Act 1995**
Land surrender Development in erosion prone areas and coastal management control districts	Assessments Permits and approvals	*Coastal Protection and Management Act 1995**
Removal of material from a marine park Discharging of wastes into a marine park Works in a marine park	Permits	*Marine Parks Act 1982*
Pollution of water, air, land	Environmental authorities and development permits	*Environmental Protection Act 1994*
Major infrastructure or other development projects such as building of dams and weirs, port construction and aquaculture	Impact assessment and approvals	*State Development and Public Works Organisation Act 1971*

*Recent amendments to the *Coastal Protection and Management Act 1995* repealed the *Beach Protection Act 1968*, the *Canals Act 1958* and the *Harbours Act 1955* and integrated the development assessment provisions from those statutes under the *Integrated Planning Act 1997*.

Tourism and recreation

Tourism is a key economic activity in Queensland, providing benefits to the local economy and community in many regional areas. However, the activities of tourists and the facilities required to service their transport, accommodation and entertainment needs place considerable pressure on coastal resources including beach and dune systems, wetlands, forests and heathlands, rocky foreshores, reef systems, estuarine waters and Indigenous cultural sites. Many of these pressures are due to the sheer size of the industry, particularly in key tourism destinations such as Cairns, Townsville, the Whitsunday Islands and south-east Queensland, where intensive development of accommodation facilities and infrastructure has taken place.

Additional pressure on other sections of Queensland's coastal zone has resulted from increased access to remote and protected areas, associated with rising rates of boat and four-wheel-drive ownership. This has been accompanied by the development of settlements and tourist infrastructure in more remote areas.

Indicators for the pressure of tourism on coastal resources are defined mostly in terms of visitor numbers and accommodation capacity. While these indicators do not directly quantify the environmental impact of tourism, they provide a relative measure of change, growth being taken to imply increasing pressure on the surrounding environment. However, more research is needed to characterise more accurately the relationship between tourist numbers and environmental impacts in coastal areas.

Table 6.8 shows estimated numbers of international and domestic visitors to Queensland coastal regions in 2002. Table 6.9 shows numbers of tourist accommodation facilities.

Tourism in the Great Barrier Reef

Tourism is now the largest commercial activity in the Great Barrier Reef Marine Park, generating up to $4.3 billion a year (PC 2003). Approximately 1.6 million tourists visit each year, the majority of tourism in the Great Barrier Reef Marine Park being centred on Cairns and the Whitsundays. Although these two areas account for less than 10% of the marine park, they receive about 85% of tourists. In 2002, approximately 730 tourism operators and 1500 vessels and aircraft were permitted to operate in the Great Barrier Reef Marine Park. About 60% of these permitted operators are actively undertaking tourism operations within the marine park. It is also estimated that 55 000 private recreational vessels are located adjacent to the Great Barrier Reef region (TQ 2002).



Aerial view of the Quicksilver platform and surrounding reef, Port Douglas (Photo: TQ)

Sustainable management

For the past six years Tourism Queensland has worked to ensure that the tourism industry in Queensland is ecologically, commercially, culturally and socially sustainable. This has involved the creation of a dedicated Sustainable Tourism Department within the state tourism agency, acknowledging the social, environmental and commercial imperative to manage and protect coastal resources. This department is responsible for the implementation of the Queensland Ecotourism Plan (QEP) 2003–08 in partnership with other relevant state and local government agencies, the tourism industry and the wider community. The QEP provides the framework for planning, developing, managing and marketing Queensland's ecotourism industry. Key priorities for the Sustainable Tourism Department in 2003–04 include:

- the Tourism in Protected Areas project, dealing with licensing and national park access for commercial operators;
- Tourism Queensland's Indigenous involvement in tourism strategy;
- continuing initiatives supporting accreditation programs such as the Nature and Ecotourism Accreditation Program (NEAP);
- the development of regional tourism networks;
- working with local government and state agencies to further tourism development;
- promoting the adoption of sustainable practices across the industry; and
- the development of self-help materials to help operators and communities build sustainable tourism businesses.

Within Queensland, the growing ecotourism industry encompasses a spectrum of nature-based activities that foster visitor appreciation and understanding of natural and cultural heritage, and are managed to be ecologically, economically and socially sustainable (TQ 2002). In 2000, ecotourism in Queensland was forecast to grow at between 10% and 20% a year (TQ 2000). In 2001 Queensland had 794 nature-based tourism and ecotourism operators, which represented 27% of the Australian total (Gutteridge, Haskins and Davey 2001).

Table 6.8 Number of international and domestic visitors to Queensland coastal region destinations in 2002 and average annual growth rates in the period 1999–2002

Destination[a]	International visitors		Domestic visitors	
	Number	Average annual growth (%)	Number	Average annual growth (%)
Gold Coast	786 078	–4.4	3 551 000	0.6
Brisbane	719 016	0.9	4 384 000	–0.3
Sunshine Coast	204 865	0.4	2 649 000	2.7
Hervey Bay/Maryborough	191 382	2.3	1 086 000	0.7
Bundaberg	45 572	0.0	610 000	–2.7
Fitzroy	95 940	–7.6	1 178 000	3.0
Mackay	31 196	–15.6	686 000	0.0
Whitsundays	209 754	1.9	426 000	0.2
North Queensland	109 063	–9.5	887 000	–5.6
Tropical North Queensland	781 097	0.8	1 273 000	1.0
Total Queensland[b]	**1 904 819**	**–1.1**	**16 329 000**	**–0.1**

[a]In some destinations visitor impact areas extend further inland than the coastal zone.
[b]Figure includes Darling Downs and outback Queensland, which are not shown in this table.

Source: BTR 2002

Table 6.9 Tourist accommodation facilities in Queensland

Accommodation type	No.	No. of beds/sites
Caravan parks with 40 or more powered sites[a]	363	42 721 sites
Letting entities—holiday flats/units/houses for short-term use with 15 or more self-contained units[a]	379	15 229 entities
Hostels with 25 or more bed spaces[a]	142	12 820 beds
Hotels with 15 or more rooms/units[b]	170	20 753 rooms
Motels/guesthouses with 15 or more rooms/units[b]	508	18 188 rooms
Serviced apartments with 15 or more rooms/units[b]	286	13 687 rooms

[a]at December 2000
[b]at September 2002

Source: ABS 2002



Cruise liner visiting Cooktown. Tourism is the largest commercial activity on the Great Barrier Reef. (Photo: L. Knight, EPA)

Case study: Managing tourism on the Great Barrier Reef

Management of tourism and recreation in the Great Barrier Reef Marine Park is a cooperative effort involving the marine tourism industry, recreational users, the Great Barrier Reef Marine Park Authority (GBRMPA) and other government agencies. The management goal is to minimise the impacts of tourism activities on the marine environment so that the diversity, integrity and productivity of the reef are maintained.

Management tools include legislation, zoning plans, plans of management, site plans, policies, permits, training and accreditation, best practice, and enforcement and management presence.

Zoning plans are established under the *Great Barrier Reef Marine Park Act 1975* (Cwlth). They state where a person may go, what a person may do and any access restrictions in the marine park. They also require all tourism operators to have a permit to operate in the marine park.

Plans of management overlay zoning plans and deal with finer-scale issues. A major element of plans of management is the ability to manage the cumulative impacts of all use.

Plans of management have been established for the Cairns area and Whitsundays specifically to deal with the high tourism use and consequent conflicts of interest (figure 6.7). Each plan identifies the natural, scientific, cultural, heritage and use values of the area and sets parameters for access to a range of sites within the area according to their value.

Each plan also includes rules on anchoring and the use of moorings, which are designed to protect corals from anchor damage, and rules limiting some activities (including motorised watersports) at environmentally sensitive locations.

Site plans for particular sites concentrate on specific use issues and cumulative impacts. These plans are developed in close consultation with local users. Site plans identify any significant values of the site and determine the appropriate balance of private and public access opportunities. Site plans, once developed and endorsed, form policy for use of that site and may be reflected in Regulations.

GBRMPA's policy statements provide guidance and predictable management for both officers of the managing agencies and users of the marine park. Formal policy lies between legislation and organisational practice. Interim arrangements and position statements also give direction as to how GBRMPA regards current tourism and recreational issues. GBRMPA has adopted policies on:

- bareboat operations in the Great Barrier Reef Marine Park;
- moorings in the Great Barrier Reef Marine Park;
- cruise shipping in the Great Barrier Reef Marine Park; and
- permits (all tourism operators in the marine park require a marine parks permit).

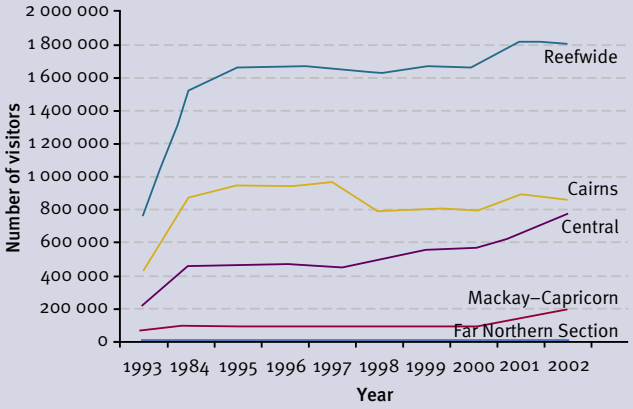


Figure 6.7 *Annual tourism use in the Great Barrier Reef Marine Park*
Source: GBRMPA

The *Great Barrier Reef Marine Park Regulations 1983* identify the issues to be considered when deciding whether to permit a proposed tourism operation and associated activities. These include:

- objectives of the zones being accessed;
- the need to protect cultural and heritage values;
- conservation of natural resources;
- the nature and scale of the proposed use; and
- the likely effect of the proposed use on adjacent areas.

The Regulations also define the conditions for suspension and revocation of permits.

Training and accreditation courses developed in conjunction with Technical and Further Education include the Great Barrier Reef Marine Park Tourism Staff Certificate Course and the Bareboat Staff Training Course (Whitsundays).

Voluntary codes of conduct and compliance with best environmental practices encourage higher standards within the marine tourism industry. Boat operators also recognise the importance of interpretive activities and employ staff with appropriate skills to inform passengers about the reef and best practices. The Queensland Code of Practice for Recreational and Sport Fishing has been collaboratively developed by recreational fishers and DPI to encourage responsible fishing and best practice.

An environmental management charge (EMC) is levied on most commercial operators with marine park permits, including operators conducting tourist programs or operating facilities in the Great Barrier Reef Marine Park. Most tourism operators pay the standard tourist program charge, equivalent to $4.50 per visitor per day, subject to concessions and exemptions. Penalties exist for commercial operators who do not maintain records or pay the required EMC. EMC data from the logbooks are used for the purposes of charging, but also provide valuable information to GBRMPA relating to tourism use of the marine park. Reef management, research and education are funded partly by the EMC paid by tourism operators.



Tourism operators in the Great Barrier Reef Marine Park require a marine parks permit. (Photo: P. Candlin, EPA)

Maritime industry

Shipping activity and shipping traffic in Queensland are increasing (figure 6.8). This growth has led to increased infrastructure associated with the maritime industry. Ports and harbours provide key trade gateways, while marinas, jetties, ramps and other recreational facilities contribute to the tourism industry. However, continued growth at the current rate will increase pressure on coastal resources, particularly wetland communities near major ports and transport corridors. Historically, pressure has also resulted from inappropriate siting of infrastructure.

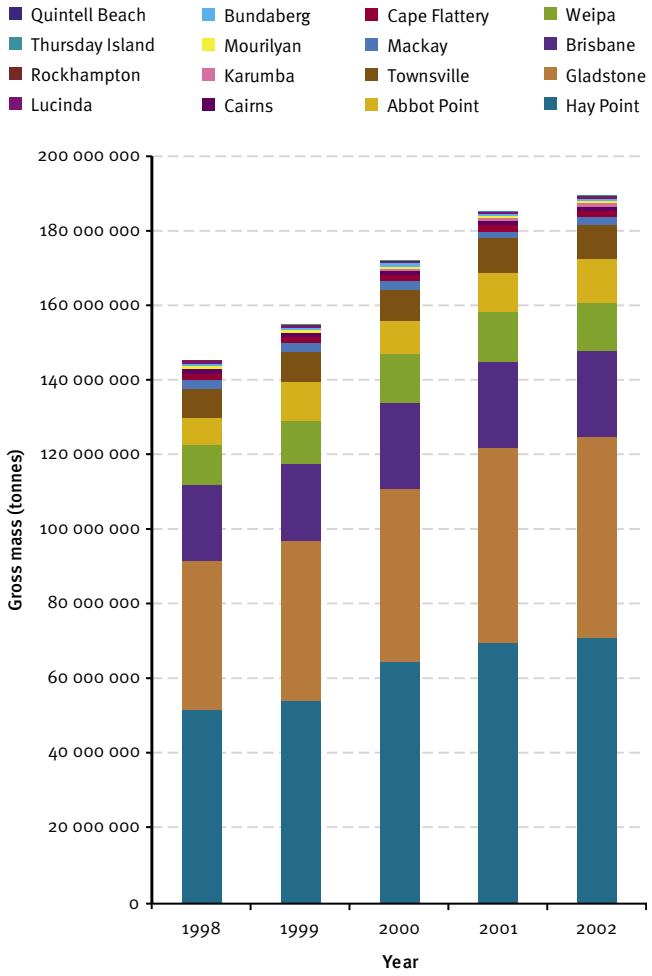


Figure 6.8 *Total throughput in Queensland ports*
Source: Queensland Transport

An example of the growth in port infrastructure is provided by the Port of Brisbane, which is undertaking a major expansion project in response to growth in all cargo types including containers, motor vehicles and bulk cargo. Cargo levels are expected to reach 61.4 million tonnes a year by 2025. Expansion at the port approved in 2002 involves extending its quayline by 1.8 km and forming port land through reclamation of 230 ha of Moreton Bay.

Port management

Ensuring the availability of suitable land for the storage, transport and port industries has been recognised as a primary function of port authorities in Queensland since the establishment of the ports system last century. Primary responsibility for port management and operations is shared among:

- eight port authorities, which are government-owned corporations operating under the *Transport Infrastructure Act 1994*; and
- Queensland Transport under the *Transport Operations (Marine Safety) Act 1994* and the *Transport Operations (Marine Pollution) Act 1995*, which regulate for marine safety, marine environmental protection and public safety.

Ports' planning powers are extensive in Queensland. Under section 169 of the Transport Infrastructure Act, ports prepare a land use plan for approval by the Minister for Transport. Port land use plans include the port-specific strategies that set the direction for future land use. The plans include details of strategic port lands, or any land the port wishes to become strategic port land, and the current and proposed uses of those lands. The plans deal with issues such as buffer zones, land for integration with other transport modes and land for use by industries requiring port facilities or that would enhance the use of the port. Higher standards are to be observed for port land use plans to ensure adequate protection of coastal values and best practice risk management of industrial land.

Under the Transport Infrastructure Act Queensland port authorities have the power to dredge and otherwise maintain or improve navigational channels within their designated port limits. Potential emerging issues are associated with the release of metals and contaminants into the water column as a result of dredging and sea dumping, and subsequent uptake into the food chain.

Best practice standards are also sought for port processes of development assessment in relation to their own developments and commercial and industrial projects for which ports are the assessment manager, under the provisions of the IP Act. A consequence of this status as assessment manager is an increased requirement for land use plans to be used as planning scheme documents, similar to local government planning schemes.

Shipping

Commercial shipping presents a significant threat by introducing non-native organisms through ballast water discharge and hull fouling (see 'Coastal habitats and biodiversity', page 6.44), as well as cargo, particularly oil spills, and contamination by anti-fouling agents (see ' Coastal water quality', page 6.28). Pressures associated with other seaborne transport activity, including private recreational boating, tourist charter vessels and commercial fishing activity, are also discussed under the headings 'Fishing, hunting and collecting' and 'Tourism and recreation'.

Maritime industry in the Great Barrier Reef

The coastline adjacent to the Great Barrier Reef World Heritage Area (GBRWHA) supports ten of Queensland's twelve major trading ports. These ports are linked by several shipping routes used for transiting the Great Barrier Reef (GBR) region. Over 3000 vessels greater than 50 metres in length use these routes each year, carrying export products such as coal, sugar and iron ore and imports such as oil and other products. Less than 10% of vessels transiting the region are oil or chemical tankers, as the majority of crude oil is transported to southern ports via routes outside the GBRWHA (the Outer Route). Approximately 75% of vessels transiting the GBR region use the Inner Route, while the remainder use Grafton, Palm and Hydrographers passages.

Within the framework established with the declaration of the Great Barrier Reef region by the International Maritime Organisation as a 'Particularly Sensitive Sea Area', the Commonwealth and Queensland governments are developing strategies to better manage shipping activities within the GBRWHA. Implemented recommendations from a review of ship safety and pollution measures in the GBR (GBRSRSC 2001) include the provision of further compulsory pilotage areas within certain areas of the GBRWHA, a mandatory ship reporting system called REEFREP and Differential Global Positioning System coverage over the entire GBRWHA. In addition, new technologies such as the automatic ship identification system are being considered as part of the development of a coordinated shipping management plan for the GBRWHA.

Oil spills

The safe passage of ships through ecologically sensitive marine areas such as the Great Barrier Reef, the Great Sandy Strait and Moreton Bay attracted national attention following the grounding of the Malaysian container ship *Bunga Teratai Satu* in the Great Barrier Reef near Cairns from 2 to 14 November 2000.

In 2001–02, 96 oils spills in Queensland waters were reported to Queensland Transport (table 6.10), the majority occurring around Brisbane. Of these, 98% were rated as not significant. This was a 19% increase on the previous year's total and is above the five-year average of 75 incidents a year. This increase may reflect improved reporting methods that were introduced in 2001 (AMSA 2002). Incidents are usually visible slicks, often attributable to oil pollution from shipping (boating) activity, but may come from other sources (figure 6.9). Reported slicks ranged in size from tens of square metres to 210 km². Between 1997–98 and 2001–02 there were eight successful prosecutions relating to oil spills (AMSA 1998, 1999, 2000, 2001, 2002).

Table 6.10 Reported pollution incidents, 1997–2001

Year	Number of oil spills	Significant incidents
1997–98	61	2*
1998–99	108	2
1999–2000	58	0
2000–01	68	2
2001–02	96	2*

* Only one of the two involved an oil discharge.

Sources: AMSA 1998, 1999, 2000, 2001, 2002

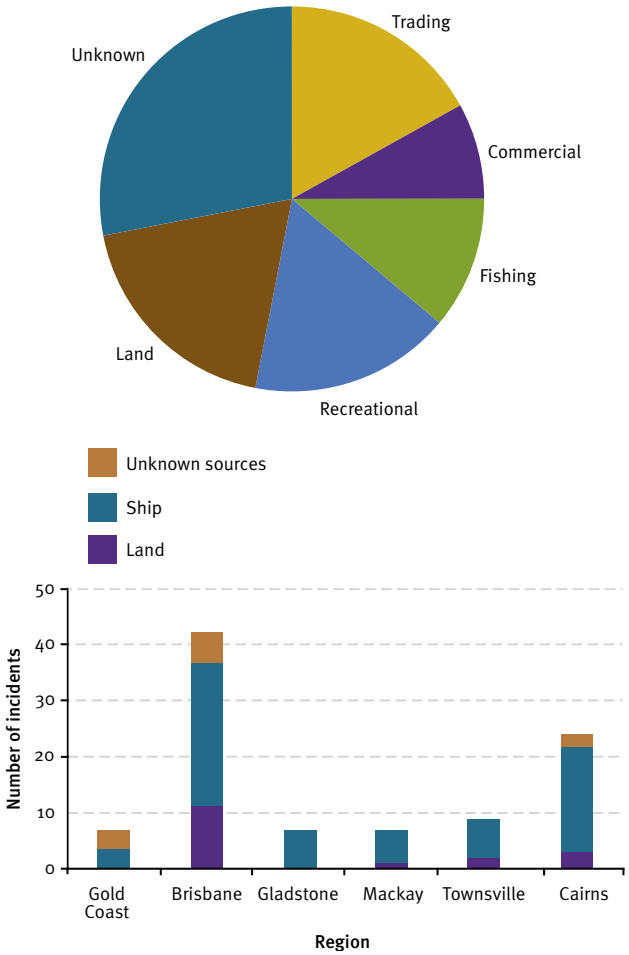


Figure 6.9 *Reported oil spill incidents by sources and region, 2001–02*
Source: QT



Reefs pose a significant navigational challenge to shipping. (Photo: EPA)

Case study: Port operations and ISO 14001

by Dr Rick Morton, General Manager Planning and Environment, Port of Brisbane Corporation

The Port of Brisbane, the third largest container port in Australia, is located at Fisherman Islands at the mouth of the Brisbane River. Fisherman Islands adjoins the Moreton Bay Marine Park, which is an area of high ecological value where many species are endangered or protected by international treaties. The port's shipping channels traverse the marine park from Caloundra to the Brisbane River.



Protecting habitat values, Port of Brisbane (Photo: L. Knight, EPA)

The significance of the surrounding environment and the Port of Brisbane Corporation's objective to lead the port industry in environmental practices have led to a culture of continuous improvement in quality, efficiency, price and productivity. As part of this improvement in management and operations, the Port of Brisbane Corporation achieved ISO 14001 certification for its environmental management system (EMS). This was the first accredited environmental management system for any port manager in Australia.

The EMS is part of the overall management system for the port. The Corporation's integrated management system (IMS) covers all activities conducted and services provided by the Corporation, including the management and development of the port, operation of port facilities such as the rail terminal, reclamation and dredging operations, and its fleet of tender vessels. The responsibility for maintaining each standard under the IMS lies with nominated senior managers.



The Port of Brisbane is the third largest container port in Australia. (Photo: L. Knight, EPA)

The use of recognised indicators, such as the ISO standard, allows the Corporation to benchmark all activities and operations against other local, national and international companies in the area of safety and environmental management. This systems approach also provides a mechanism for continual improvement in its operation towards world's best practice.



Rail link, Port of Brisbane (Photo: L. Knight, EPA)

Resource extraction

Mining and mineral processing industries are Queensland's most important source of revenue. Mineral resources in the coastal zone include silica and mineral sand (figure 6.10), limestone, tin, gold and other commodities. Some of Queensland's coal and petroleum resources also lie in the coastal zone.

Most silica sandmining activity occurs at Cape Flattery, north Queensland, and most production is exported. In 2000–01, 2.6 million tonnes of silica sand were mined, representing a substantial increase on the 670 000 tonnes produced in 1980.

The major components of heavy mineral sands, rutile, ilmenite and zircon, are used as paint pigments and in foundry applications. Virtually all of Queensland's mineral sands are derived from mining operations on North Stradbroke Island. Production of mineral sand components in 2000–01 was:

- 65 000 tonnes of rutile, an increase of 27% on the previous year; and
- 43 000 tonnes of zircon, a 20% increase on the previous year.

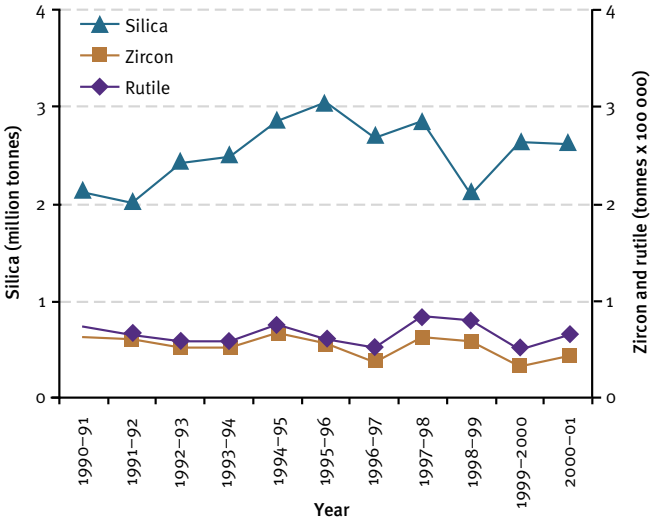


Figure 6.10 *Mineral sands production*
Sources: Queensland Department of Minerals and Energy, Queensland Government Mining Journal, *and* Queensland Minerals and Energy Review/Petroleum Review

Extraction of sand, gravel, rock and sediment provides important materials for industry but can also have significant impacts on coastal resources. Pressures on the environment may include beach instability, disturbance to fisheries and degraded water quality. Dredging also provides important economic benefits, but can be a significant pressure on coastal resources if not appropriately managed.

Table 6.11 shows the number of approved extractive industries in tidal waters and the volume of dredging material removed between 1 July 1999 and 30 June 2002.

Table 6.11 Number of dredging sites and volumes of materials removed between 1 July 1999 and 30 June 2002

Purpose	Dredging sites	Quantity removed (m³)
Sale	52	1 724 173
Reclamation and other	34	4 420 692
Total	**86**	**6 144 865**

Source: EPA

Since 2001 the environmental regulation of mining in Queensland has been managed by the EPA under the EP Act. The regulatory framework sets levels of environmental assessment for new applications, sets environmental conditions, monitors performance, conducts inspections and audits, ensures adequate rehabilitation, and enforces compliance with environmental controls.

Policy direction for dredging and the extraction of sand, gravel, rock and sediment is provided in the State Coastal Plan.

Fishing, hunting and collecting

Fishing, hunting and collecting have direct impacts on the species/taxa in the estuarine and marine environment. Harvesting of finfish, crabs, prawns, squid, scallops and bugs throughout Queensland is undertaken mainly by the commercial and recreational sectors. The commercial sector is licensed by the government to harvest seafood either for consumption by the Australian community or for sale overseas to generate export income for Australia. Indigenous communities harvest these and other species such as dugong and turtle for customary and subsistence purposes.



Prawns are a commercially significant catch. (Photo: EPA)

In addition to harvest pressures, climatic effects, declines in habitat health and area, predation by other animals and natural mortality have impacts on fish stocks. Increase in the human population in coastal areas also results in coastal development, habitat destruction, runoff and pollution. These effects place both direct and indirect pressure on fish stocks. The level and effect of many of these pressures are difficult to quantify. However, the performance of a fishery/fish stock can provide a useful indicator of the status and health of an estuary or marine environment.

The Queensland Fisheries Service (QFS), Department of Primary Industries develops fishery management plans under the *Fisheries Act 1994*. These plans essentially aim to manage fishing pressure in a particular fishery depending on the judgments made about the status of the fish stock. Table 6.12 shows the management plans that have been or are being developed for all the main marine fisheries in Queensland.



Fish stocks are a useful indicator of the status and health of an estuary or marine environment. (Photo: CRC Reef)

Table 6.12 Dates for the implementation of fishery plans in Queensland

Fishery	Fishery plan implementation date
Crab (mud and blue swimmer)	Planned for 2006
Coral reef finfish	2003
East coast inshore finfish	Planned for 2005
East coast trawl	1999
Gulf of Carpentaria inshore finfish	1999
Spanner crab	1999

Source: DPI

As part of the process of managing Queensland's fish stocks sustainably, ecological assessments are being undertaken so that the export-orientated fisheries, such as trawl, can be accredited under the EPBC Act. They are expected to be completed by December 2004.

Fishery management plans in Queensland use a mixture of input and output controls depending on the fishery. Input controls, for example, restrict the number of vessels that can operate in a fishery (all Queensland commercial fisheries are limited entry), and specify the time and place for fishing (applies to both commercial and recreational fishers) and/or the type and specification of both vessel and gear. Output controls can restrict level of catch (bag limits for recreational fishers) or days fished by individual boat quota, or restrict size, gender or maturity stages of fish that can be harvested (applies to commercial and recreational fishers). Output controls may also apply to the levels and composition of bycatch and by-product.

Input controls in the east coast otter trawl fishery include gear size restrictions, area and time closures to fishing, and restrictions in boat size and fishing effort, for both total effort in the fishery and effort quotas (viz. a maximum number of fishing days) for each boat. Figure 6.11 shows the distribution of total fishing effort in the fishery in 2001. Output controls include minimum legal sizes for some species (such as bugs), limits on the quantity of by-product species that can be kept (such as blue swimmer crabs), and no-take provisions for other species (such as whiting). In addition, otter trawlers have to install devices in the trawl nets to minimise trawl bycatch as well as to automatically release protected animals such as turtles. Similar concepts are applied to other fisheries, although the mixture of controls may differ.

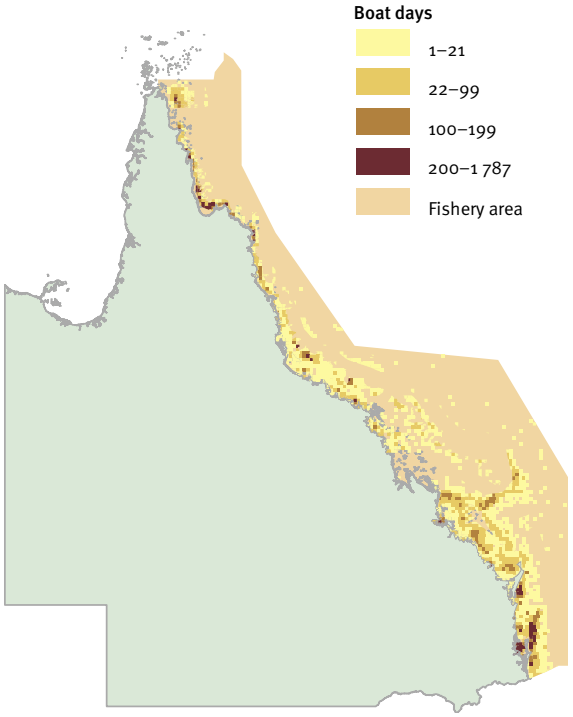


Figure 6.11 *Fishing effort in the east coast otter trawl fishery in 2001*
Source: DPI

The Fisheries Act allows for development of procedures outside the management plan so that concerns about a particular species due to a change of circumstances can be taken into account. For example, harvest of tailor by both commercial and recreational fishers has been restricted recently because of concerns about the status of the tailor stock.

The optimum sustainable harvest level for many of Queensland's fisheries or fish stocks is difficult to determine due to the inherent natural variability of fish stocks as well as the environmental effects of population pressures adjacent to the coast and the flow-on effect from them, which are hard to quantify. Information about climate, fishery habitat, fisher behaviour, fish behaviour and fish biology is required to undertake fishery modelling.

To assist in assessing the sustainability of Queensland's fisheries, QFS:

- has collected detailed data from all commercial fishing boats since 1988;
- undertakes statewide recreational fisher surveys so that the harvest may be estimated;
- undertakes economic surveys of commercial fisheries; and
- collects fishery-independent data for key species using a long-term monitoring program.

QFS also undertakes or encourages other agencies to conduct research into fisheries, particular species or fishery systems to support improvements in the management arrangements that will ensure the sustainability of Queensland's managed fisheries.

Table 6.13 summarises key information about the main fish stocks/fisheries in Queensland. It shows the assessments carried out for key species harvested in Queensland and provides resource risk judgments for those species.

Table 6.13 Summary of performance of important Queensland fish stocks

Major species/groups	Commercial catch (t) Mean 2000–02	Commercial catch trend[1]	Estimated recreational catch compared to commercial catch[2]	Assessment[3]	Resource risk[4]
East coast trawl					
Banana prawns	400	Variable	One-quarter	Fishery	Low
Endeavour prawns	1200	Neutral	NA	Stock	Low
Northern king prawns	800	Increase	NA	Stock	Low
Eastern king prawns	2300	Increase	NA	Stock	Low
Tiger prawns	1600	Neutral	NA	Stock	Medium
Bugs	480	Neutral	NA	Preliminary	Medium
Saucer scallops (meat)	800	Variable	NA	Stock	Medium
Stout whiting[5]	800	Decline	NA	Stock	Medium
Squid	140	Variable	NA	Fishery	Low
Subtropical inshore and estuarine					
Yellowfin bream	180	Neutral	Four times	Fishery	Low
Swallowtail dart	30	Neutral	Five times	Fishery	Low
Dusky flathead	60	Neutral	Three times	Stock	Medium
Mullet	2100	Neutral	NA	Fishery	Medium
Tailor	200	Neutral	Two times	Stock	Medium
Inshore whiting	300	Neutral	Two and a half times	Fishery	Low
Tropical inshore and estuarine					
Barramundi	950	Increase	One-fifth	Stock	Low
Threadfin—blue	200	Neutral	Unknown	Preliminary	Low
Threadfin—king	500	Neutral	Unknown	Preliminary	Medium
Reef line					
Coral trout	2000	Increase	One-fifth	Fishery	Medium
Red-throat emperor	800	Increase	Four-fifths	Fishery	Medium
Crab					
Mud crab	1000	Increase	Equal	Preliminary	Medium
Blue swimmer	950	Increase	One-quarter	Preliminary	Low
Spanner crab[5]	1900	Decline	NA	Stock	Low
Other finfish					
Grey mackerel—east coast	80	Decline	Unknown	Fishery	Medium
Grey mackerel—Gulf[6]	400	Increase	Unknown	Preliminary	High
Spanish mackerel	800	Decline	Two-thirds	Stock	Medium
Spotted mackerel	300	Increase	Equal	Stock	Medium
Shark	1500	Increase	NA	Preliminary	High
Snapper	100	Stable	Three times	Fishery	High

NA = not applicable (not a recreational species)

[1] Trends allow for variation and usually consider changes from 1990 to 2002.

[2] Commercial catch of dusky flathead is about 60 t per year and recreational catch is estimated to be about three times that, that is, about 180 t per year.

[3] 'Stock' indicates a detailed quantative stock assessment as well as a fishery assessment. 'Preliminary' indicates that a fishery assessment has been carried out and a formal stock assessment is currently being carried out. 'Fishery' indicates that a review of that fish stock has been carried out through assessment of catch, and rate measures such as catch per unit of effort or days fished per boat per year.

[4] Risk ratings of fish stock sustainability are based on assessment by experts for each species incorporating biological, climatic, fisher harvest performance and other factors. 'Low' indicates low risk of being fished unsustainably; 'Medium' indicates medium risk of being fished unsustainably; and 'High' indicates high risk of being fished unsustainably.

[5] Stout whiting and spanner crabs are catch quota-managed fisheries.

[6] Gulf of Carpentaria

Bycatch

Since 1999, measures have been taken to reduce the harvest of non-target species in Queensland's trawling industry. Use of bycatch reduction devices (BRDs) has been compulsory under the Trawl Plan since 1 July 2001. Compliance with this provision is expected to significantly contribute to achieving the 40% reduction in bycatch by the beginning of 2005 that is proposed under the Trawl Plan.



The trawling industry is taking measures to reduce the harvesting of non-target species. (Photo: EPA)

An estimated 55% reduction in bycatch has been achieved through the adoption of BRDs during experimental trawls in the banana prawn trawl sector, which contributes about 7% of the total landings of Queensland's trawl fisheries (Stobutzki et al. 1999). Research due for completion by 2004 will determine the composition and abundance of bycatch in the scallop, eastern king prawn and tiger/endeavour prawn sectors of the east coast otter trawl fishery. The data are also being used to estimate and compare the effects of BRDs and turtle excluder devices (TEDs) fitted to the commercial trawl gear of boats in each trawl sector.

Catch comparisons for bycatch and target species between standard trawl gear and gear modified with a BRD and TED fitted to the net are available from specially commissioned chartered trawls in the tiger prawn and eastern king prawn sectors of the fishery (table 6.14). It appears that there may be potential to reduce bycatch in these prawn fisheries by 9–78% using an appropriate BRD and TED fitted to each net. Before the introduction of TEDs, the primary cause of death of turtles caught in trawl nets was drowning (Haines et al. 1999). TEDs exclude not only turtles but also large fish such as sharks, rays and large sponges that provide habitat for bottom-dwelling species.

Amendments to the compulsory 'OT07 trawl fishery logbook' are designed to ensure compliance with bycatch reduction measures. Since January 2001, trawler operators have been required to record the use of BRDs and the type of BRD fitted. There are also logbook provisions for recording the type of TED that is fitted. Non-target, commercially valuable species taken and retained as by-product must also be recorded under the Trawl Plan. Other non-target bycatch species (excluding sea turtles), which are usually brought on board and sorted from the targeted product, are discarded without being recorded.

In January 2003 a new trawl logbook (OT08) was introduced. It requires comprehensive gear descriptions for each target species, linked to individual fishing operations reported by operators. This will allow the development of detailed spatial analysis of the use of different types of fishing gear across Queensland in relation to fish capture and fishing effort. A new logbook reporting captures of species of conservation interest (SOC101) was introduced at the same time. Individual fishing operators are required to record all interactions with species listed and report details to the QFS at the end of each month.

Table 6.14 Effects of bycatch reduction devices on the weight of bycatch and target species obtained during experimental research charters

Target species	TED/BRD modification	Reduction of bycatch	Effect on target species
Tiger/endeavour prawns	TED + radial escape section	Marginal (9%)	Not significant
Shallow water eastern king prawns (30–100 m)	TED + radial escape section	26%	17% reduction
Deep water eastern king prawns (100–200 m)	TED + square mesh codend	29%	Not significant
Scallops	TED + square mesh codend	Total bycatch–78% Excluding sponges–60% Excluding sponges, sharks and stingrays–57%	Not significant for commercial-sized catch; 63% reduction in undersized catch

Sources: Courtney 2002; Courtney and Campbell 2003a–d

Hunting

Hunting is largely restricted to Indigenous hunting of dugongs and turtles in north Queensland and Torres Strait. While not widespread, it constitutes a pressure on target species. Collection or harvest fisheries include bêche-de-mer, tropical rock lobster, trochus, aquarium fish and coral.

Aquarium fish collection

Damsel fish, wrasses, butterfly fish and angel fish are the most frequently captured marine aquarium fish species collected. The number of commercial marine aquarium fish collectors declined significantly from a peak of 160 licences in 1990 to 54 in August 2003. Numbers of fish caught in the fishery also declined in recent years from about 248 000 in 1998 to about 179 000 in 2002 (figure 6.12). This decline reflects changing market demand for certain species and reduced fishing effort (boats and the reported time spent fishing) from fewer licensed fishers, rather than any real decline in marine aquarium fish abundance.

Table 6.15 lists average annual catches for the major species groups as a percentage of the total catch between 1998 and 2002.

Table 6.15 Major species groups as a percentage of the total commercial aquarium fish catch between 1998 and 2002

Species group	Percentage of total catch
Damsel fish	21.7
Wrasse	10.9
Butterfly fish	10.6
Angel fish	8.2
Gobies	7.0
Clown fish	5.3
Invertebrates	4.9
Surgeon fish	4.6
Fish—unspecified	6.5

Source: DPI

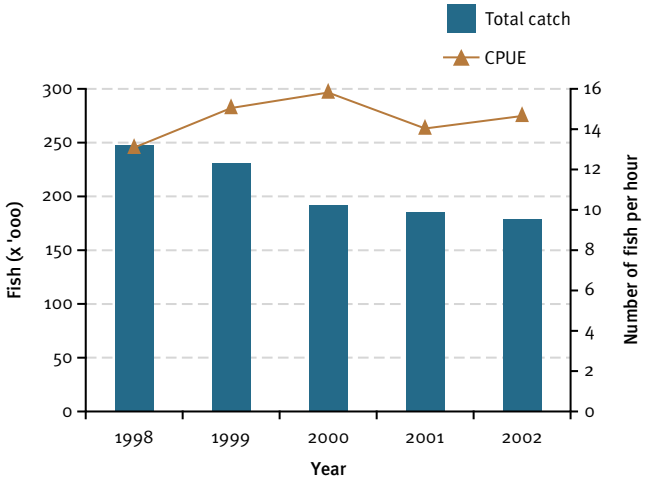


Figure 6.12 *Annual catch and catch per unit of effort (CPUE) estimates for the marine aquarium fish fishery, 1998–2002*
Source: DPI

Aquaculture

Aquaculture has been identified as a potential growth industry in Queensland with the capacity to generate regional economic wealth and social benefits. Land-based aquaculture activities include the cultivation of live fisheries resources.
The operations range from activities with no discharge of wastes, such as freshwater tank recirculating systems and freshwater ponds and dams, through to activities which take in, use and discharge to coastal waters, such as intensive pond-based systems.

The major pressures associated with aquaculture relate to the farm's location and the amount and quality of its waste discharged into tidal waterways. Figure 6.13 shows the distribution of aquaculture farms and table 6.16 gives the area by location and type.

The quality of discharges released from aquaculture activities is dealt with by the EPA under the EP Act and the *Environmental Protection (Water) Policy 1997* (Water EPP). The management and containment of diseases, as well as the overall management of impacts on marine plants and fisheries habitats, are dealt with by DPI under the Fisheries Act. DPI's policy on aquaculture activities does not support their location below highest astronomical tide (with the exception of intake and discharge infrastructure).

The Commonwealth's *Great Barrier Reef Marine Park (Aquaculture) Regulations 2000* apply to aquaculture in areas bordering the Great Barrier Reef Marine Park. The purpose of the regulations is to regulate the discharge of waste from aquaculture operations, which may affect animals and plants in the Great Barrier Reef Marine Park.

Table 6.16 Aquaculture ponded areas (ha) by type and location, 2000–01

Statistical Division	Barramundi	Crayfish	Eels	Hatchery	Prawns	Freshwater fish	Total
Brisbane	8	3	0	0	127	0	138
Moreton	0	27	4	18	0	3	52
Wide Bay	1	47	0	16	62	25	151
Darling Downs	0	4	0	7	0	15	26
South West	0	0	0	0	0	0	0
Fitzroy	0	25	0	5	0	1	31
Central West	0	0	0	0	0	0	0
Mackay	3	7	0	0	135	1	146
Northern	6	5	0	0	176	0	187
Far Northern	164	22	1	3	165	2	357
North West	0	0	0	0	0	0	0
Offshore	0	0	0	0	0	0	0
Total	**182**	**140**	**5**	**49**	**665**	**47**	**1088**

Source: DPI

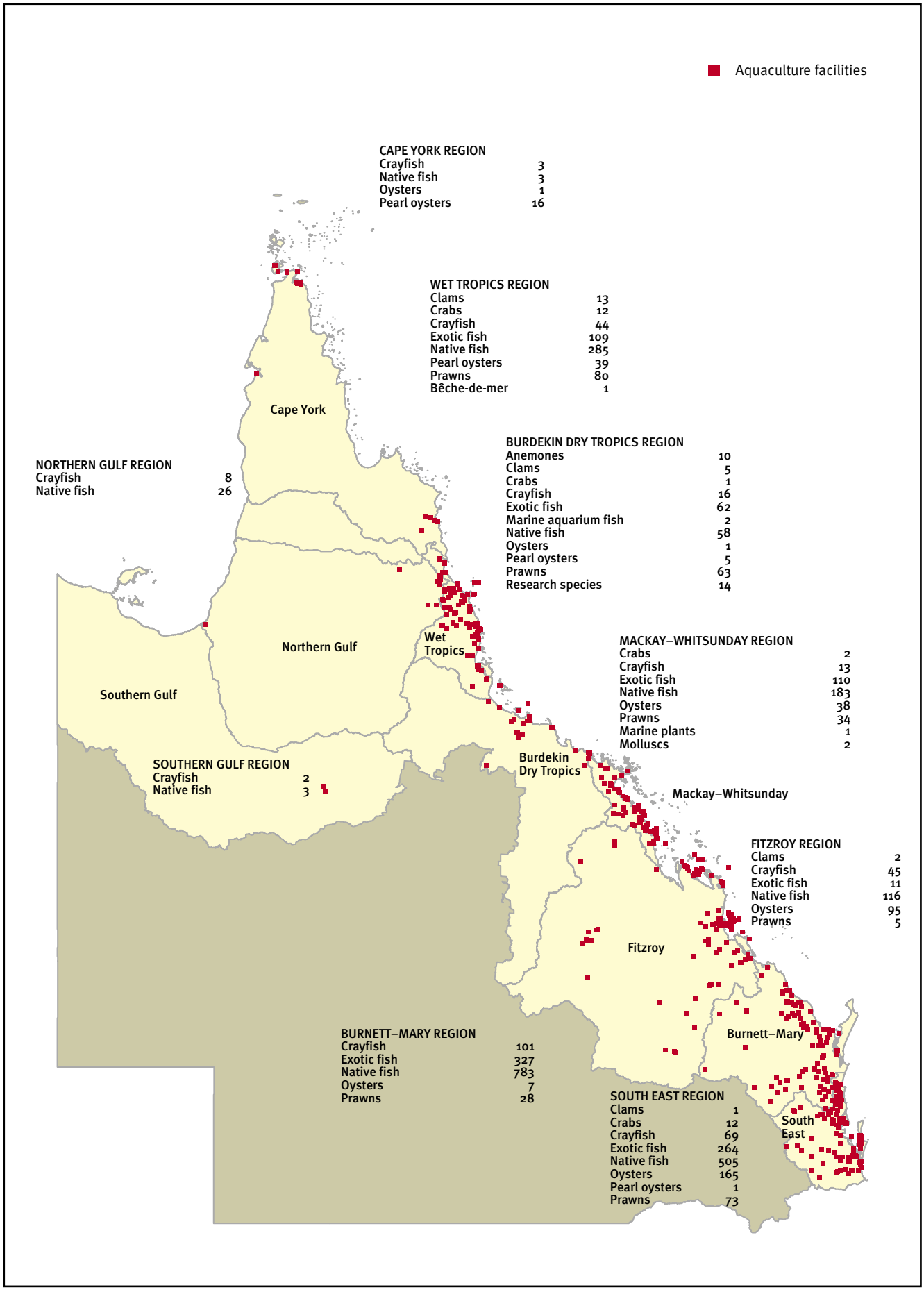


Figure 6.13 *Distribution and number of aquaculture farms by type in Queensland at June 2002*
Sources: DPI and EPA

Coastal water quality

Summary

Diffuse and point source discharges of nutrients, sediments and contaminants such as heavy metals and synthetic agricultural and industrial chemicals pose a significant risk to the ecological condition of coastal and estuarine waterways. With continued population growth and development in the coastal zone, it can be expected that more water will be needed and more wastewater will be generated. Unless the pressures on coastal water quality are firmly managed and progressively reduced, undesirable and costly ecological, health and economic impacts are likely.

Regional assessments of coastal water quality condition found that sites in the Burdekin, Mackay–Whitsunday and south-east Queensland regions most commonly experienced poor water quality. Phosphorus and nitrogen were the two indicators contributing to this rating. Metals bioaccumulated in prawns, shellfish and other marine fauna were greatest in south-east Queensland waterways, particularly canals, and occasionally exceeded Australian food quality standards. In central and north Queensland the persistence of pesticides and herbicides, including a number of banned substances, in sediment, seagrass and some marine mammals is an issue.

Current and future efforts to deal with water quality centre on integrating coastal and catchment management, setting and assessing water quality targets and working with communities and industries to reduce and recycle wastewater. Discharges of nutrients from point sources have been reduced significantly in the past five years through concerted efforts to upgrade treatment technology and amalgamate and reduce the number of actual discharges. While there have been localised improvements in reducing diffuse inputs, managing and progressively reducing these inputs to the coast remains a great challenge for Queensland in the next five years. Initiatives such the Reef Water Quality protection plan, the National Action Plan for Salinity and Water Quality and the Natural Heritage Trust will develop catchment-specific nutrient targets to further drive management actions to reduce sediment and nutrient loads. To improve our knowledge of coastal water quality and monitoring of its effect on aquatic resource condition, resources will need to be augmented and better coordinated to provide more comprehensive and timely information on basic water quality indicators, conduct targeted regional assessments of contaminants and deal with significant knowledge gaps such as the inadequacy of water quality data from the Gulf and Cape York regions.

Description

A variety of human activities occurring within and adjacent to a catchment can contribute to changes in water quality. Unsustainable land use practices such as land clearing, removal of riparian vegetation and excessive stocking rates increase mobilisation of soil (sediment) and expose acidic soils. Inappropriate application of fertilisers, pesticides and herbicides on crops and the discharge of domestic and industrial wastes from point source discharges and stormwater overflow affect water quality in adjacent waterways.

The pressures on coastal and estuarine water quality need to be firmly managed and progressively reduced to prevent undesirable impacts such as loss of biodiversity and habitat, fisheries production and visual and recreational amenity; increased incidence of algal blooms; fish kills; and increases in the number of invasive species. Failure to do so may lead to a number of socioeconomic consequences including loss of income (tourism and fisheries), the need for costly remediation technologies (in areas such as water treatment and site rehabilitation), negative health outcomes and associated costs, as well as community concern.

The major issues relating to definitions of good or poor water quality are the presence, concentration or load of:

- nutrients—the oversupply of nutrients, principally nitrogen and phosphorus, can lead to organic enrichment (eutrophication) resulting in outcomes such as increased algal blooms, which, if unchecked, can have significant health, recreational and commercial repercussions such as the closure of fisheries and swimming areas;
- sediments—oversupply of sediments increases the turbidity of water, reducing the light available to plants for photosynthesis. It can also smother and abrade benthic organisms;
- bioaccumulated contaminants—pesticides, herbicides, heavy metals and other endocrine-disrupting chemicals used by industry and released, either deliberately (as point discharges) or accidentally (as chemical spills), to coastal and estuarine waters can accumulate in plants and animals, and have adverse physiological effects. Subsequent human consumption of contaminated seafood can result in a range of mild to severe health outcomes;
- pathogens—human faecal contamination of drinking water can potentially lead to gastroenteric and respiratory illnesses in humans participating in recreational activities in the water;
- litter—the introduction of litter, such as cigarette butts and plastics, may choke aquatic fauna including birds, fish and marine mammals and reptiles;
- flow—while flow was often considered a separate issue from water quality, there is now widespread recognition that sustainable and variable flows of water help to prevent algal bloom formation and are an important cue for the spawning of estuarine fishes. Recent droughts have highlighted the fact that healthy estuarine and coastal water quality is also essential to definitions of water quality; and
- acid sulfate soils—in exposed low-lying coastal areas acid sulfate soils can result in disease and death of fish, and cause deterioration in concrete, steel and road infrastructure.



Water quality assessment (Photo: EPA)

Pressures

The water quality and ecological condition of Queensland's estuarine and coastal waterways are integrally related to surrounding and upstream land use activities. Coastal and estuarine water quality is affected by:

- wastewater discharges;
- land clearing and loss of riparian vegetation;
- alterations to surface water flows;
- agriculture;
- aquaculture; and
- land-based and shipping industries.

Wastewater discharges

It is still common practice to discharge domestic and industrial wastes—a cocktail of sediments, nutrients and contaminants—to nearby estuarine and coastal waterways. These point sources or wastewater treatment plants (WWTPs) can include domestic sewage treatment plants (STPs), industrial or agricultural facilities (such as piggeries and feedlots) and mining discharges.



Upgrades at sewage treatment plants in south-east Queensland have reduced the nitrogen and phosphorus loads being discharged into Moreton Bay. (Photo: EPA)

In south-east Queensland nutrients discharged via wastewater discharges account for approximately 40% of the total nitrogen and 60% of the total phosphorus released to coastal and estuarine waters; elsewhere in the state they typically account for less than 10% (figure 6.14). The standard of this effluent, the quality of the receiving waters and their capacity to absorb additional nutrients and other contaminants vary along the coast. Accidental spills and overflows of domestic untreated sewage can also occur, mostly as a result of wet weather infiltration or pump station failures.

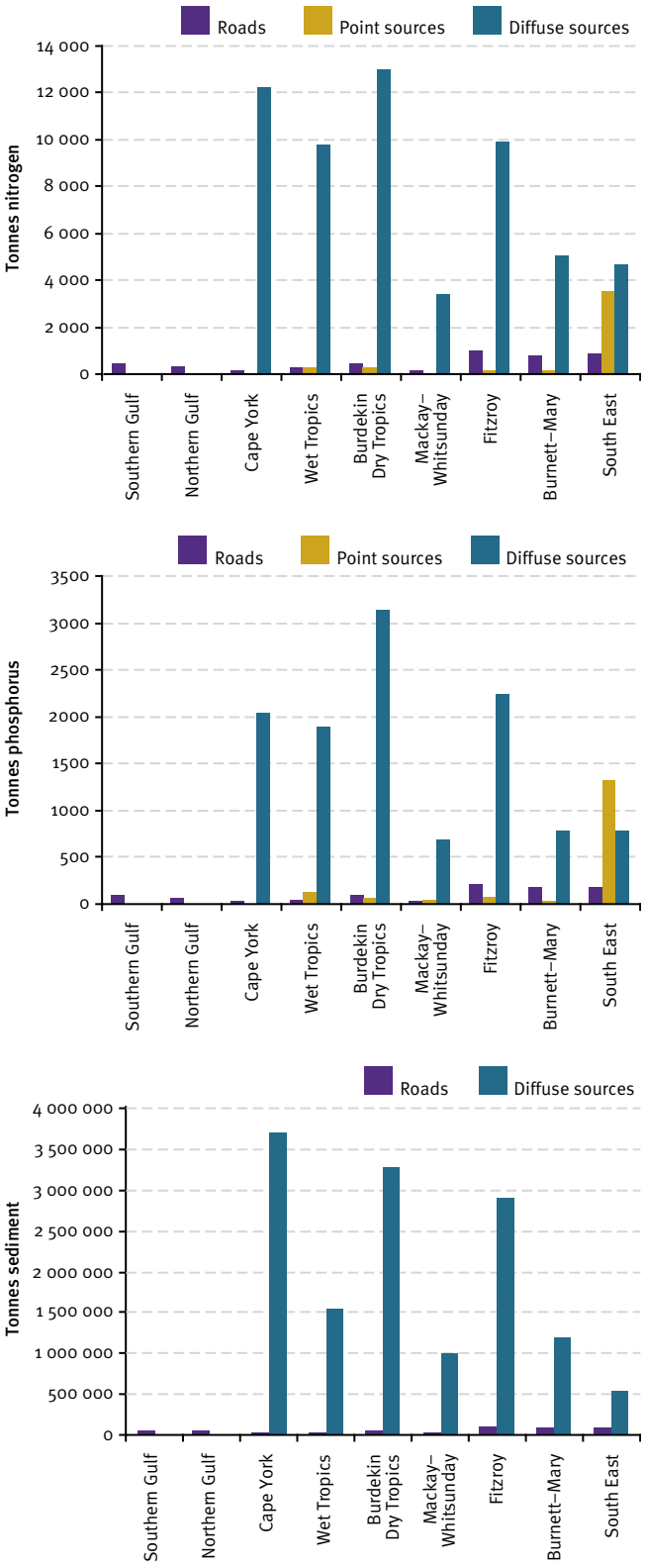


Figure 6.14 *Relative contribution of point sources (wastewater treatment plants), diffuse sources and impervious surfaces to annual catchment loads (tonnes) of nitrogen, phosphorus and sediment in Queensland NRM regions*

Sources: WWTP data from local governments; diffuse sources are taken from SEDNET predictions (NLWRA 2002); impervious surfaces are calculated from runoff coefficients (WBM 2002) scaled to the area of road in each region.

Over 200 STP discharges throughout Queensland are currently licensed and many of these discharge to coastal waters. Since 1999, many of the larger STPs in south-east Queensland have significantly reduced nutrient discharges through concerted efforts by local governments to upgrade treatment technology (Caboolture Shire), decommission old plants (Logan City), amalgamate discharges (Gold Coast City), or divert discharges to more suitable receiving environments (Maroochy Shire) (table 6.17). This has resulted in a reduction in nitrogen loads across the region of almost 35%. Significant reductions in phosphorus loads from some STPs, notably on the Gold Coast, have been offset by increases from other plants discharging into or close to Moreton Bay; across the region phosphorus loads have been reduced by more than 4%. In north Queensland upgrades to some of the smaller plants have reduced nitrogen and phosphorus discharges by 30–90%.

Table 6.17 Nitrogen and phosphorus discharges from selected wastewater treatment plants in 2001–02 and the percentage change in nutrient discharge since 1999

Wastewater treatment plants	Nitrogen		Phosphorus	
	2001–02 load (kg)	Change since 1999 (%)	2001–02 load (kg)	Change since 1999 (%)
South-east Queensland				
Luggage Point	350 035	–66	408 800	–20
All Gold Coast plants	226 139	–40	156 475	–43
Redcliffe	20 212	–91	4 513	–89
All Ipswich plants	120 401	–34	–	–
Pine Rivers Shire	55 000	–75	34 700	-21
North Queensland				
Gordonvale	6 410	–75	2 959	–57
Babinda	5 625	–36	1 607	–31
Atherton	3 105	–80	621	–93
Port Douglas	4 748	–80	950	–93
Queensland total	**2 919 000**	**–30**	**1 508 000**	**–4**

Source: EPA

In non-sewered areas in south-east Queensland and along the Queensland coast, it is estimated there are approximately 225 000 septic tanks and 25 000 household sewage treatment plants. The environmental impacts of these facilities depend on the effectiveness of the facility and maintenance by the property owner.

Land clearing and loss of riparian vegetation

Vegetation clearing leads to increased flows, erosion and delivery of nutrients and sediments from catchments to adjacent waterways as a result of the loss of the natural filtering systems provided by riparian areas and coastal wetlands. Soil and nutrient losses increase significantly when vegetation cover (particularly grasses) falls below 40%, or when pastures are overgrazed or overburnt for the prevailing climate and pasture growth conditions.

In south-east Queensland, only 26% of the catchments' original vegetation remains. Channel (gully and stream bank) erosion is the dominant form of erosion in these catchments, with more than 60% of the sediment coming from less than 30% of the area (figure 6.15).

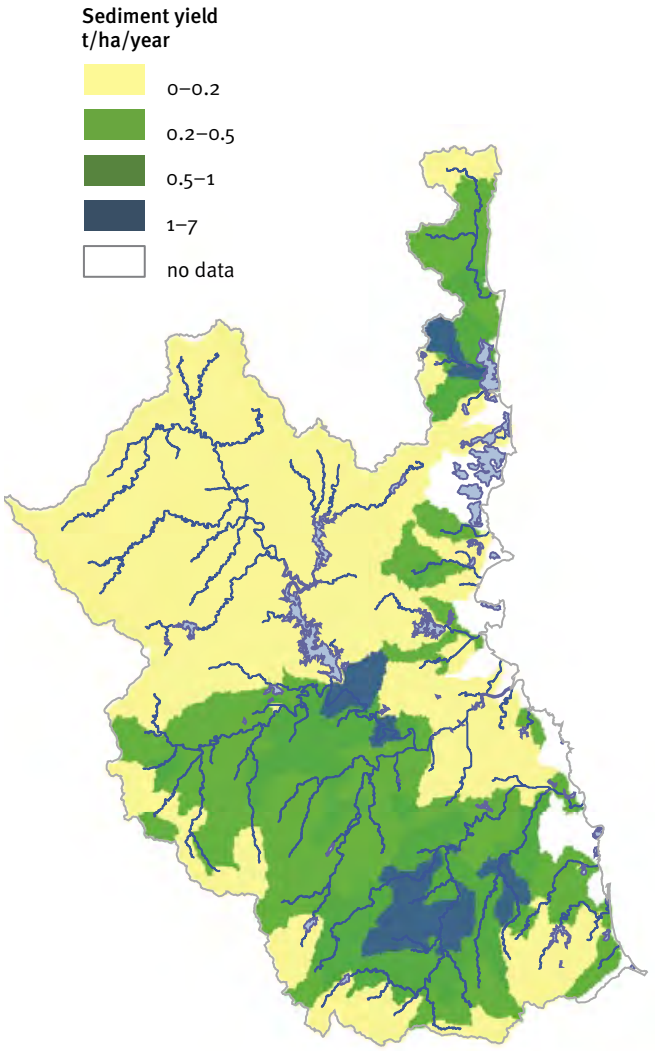


Figure 6.15 Predicted contribution of different areas in the catchments to sediment loads in Moreton Bay, as determined by SEDNET predictions
Source: CSIRO Land and Water

In catchments adjacent to the Great Barrier Reef, vegetation clearing continues, the coastal lowlands and wetland areas being under the greatest pressure. Here, hill slope erosion dominates, supplying 63% of sediment to rivers (Brodie et al. 2003). Gully and riverbank erosion can also be significant but these are confined to a few catchments. Overall, 70% of sediment delivered to the coast comes from just 20% of the catchment area. The areas responsible for the highest contribution are relatively close to the coast, from the Burnett–Mary to the Fitzroy, from Mackay to Bowen, and in the Wet Tropics and the Normanby River basin (figure 6.16).

Soil erosion in these catchments is also the greatest source of particulate nutrients, gully and riverbank erosion accounting for less than 10% of the total nutrient sources. Total loads of nitrogen and phosphorus delivered to the coast largely reflect soil erosion patterns because particulate nutrients, resulting primarily from hill slope erosion, account for more than 70% of total nutrient sources.

Acid sulfate soils are present along much of the Queensland coast. Acidic water draining from disturbed acid sulfate soils is generally poorly oxygenated, has a low pH and may contain elevated concentrations of heavy metals and aluminium. These conditions have the potential to have adverse impacts on fish habitat and health.

Alterations to surface water flows

Reductions in vegetation cover and increases in areas of impervious surfaces such as roads and built urban environments can significantly increase the volume and alter the pattern of surface water runoff to nearby waterways, leading to increased nutrient, sediment and contaminant loads. In urbanised south-east Queensland catchments, it is estimated that roads contribute approximately 10% of total nutrient and sediment loads.

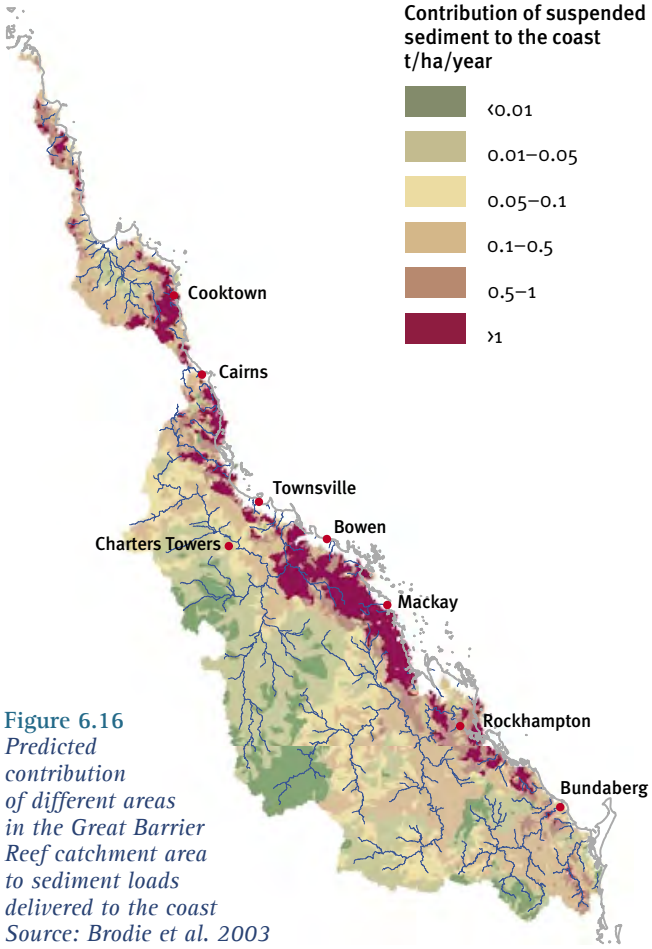


Figure 6.16 *Predicted contribution of different areas in the Great Barrier Reef catchment area to sediment loads delivered to the coast*
Source: Brodie et al. 2003

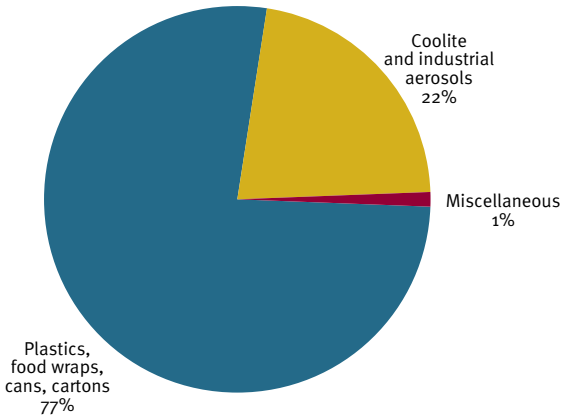


Figure 6.17 *Rubbish collected from the Brisbane River, December 2001 to October 2002.*
Source: Maritime Care

Carelessly discarded litter eventually finds its way into waterways. While litter is widely regarded as a significant environmental issue, relatively little quantitative information is available. A Maritime Care study in 2002 covering an 80 km stretch of the Brisbane River collected more than 160 000 items of rubbish over a 10-month period; plastics, food wrapping, cartons and cans accounted for more than 77% of this litter (figure 6.17).

The construction of dams, weirs and barrages to meet the needs of agriculture, industry and urban development has led to flow regulation of rivers, which can impair the chemical, physical and biological characteristics of estuarine and coastal habitats and potentially limit fisheries resources by inhibiting the passage and spawning of fishes. Dams change both the volume and pattern of flows downstream in the catchment by attenuating periods of naturally high flow but often eliminating low flows altogether during dry periods. All 13 Natural Resource Management (NRM) regions are now subject to some degree of flow regulation (table 6.18).

Table 6.18 Catchment area, number of streams, number of dams and weirs and storage capacity, and largest dam in each of Queensland's NRM regions in 2000

NRM region	Total catchment area (km²)	Number of streams	Number of dams and weirs	Total dam and weir capacity (ML)	Largest dam
Coastal					
Southern Gulf	106 595	201	28	200 000	Flinders River d/s 828.5
Northern Gulf	47 044	179	19	20 600	Copperfield River George Dam
Cape York	8 310	171	4	135	Two Mile Creek Weir
Wet Tropics	14 855	77	42	666 889	Tinaroo Falls Dam
Burdekin Dry Tropics	1 361 966	155	75	2 468 058	Burdekin Falls Dam
Fitzroy	3 098 770	258	174	4 286 226	Fairbairn Dam
Mackay–Whitsunday	12 578	38	43	749 804	Peter Faust Dam
Burnett–Mary	996 996	300	244	1 449 518	Fred Haigh Dam
South East	1 165 200	154	173	2 408 552	Wivenhoe Dam
Inland					
Murray–Darling	1 255 465	298	202	254 000	Glenlyon Dam
Desert Channels	273 259	271	10	50 585	Lena Creek No. 8 Tailings Dam
South West	125 855	72	7	3 520	Cunnamulla Weir
Desert Uplands	103 624	226	10	457	Charles Lloyd Jones Weir

Source: DNRM

Agriculture

The major agricultural land use in catchments adjacent to the Great Barrier Reef is grazing (77%) on native or improved pastures; cropping of sugar, horticulture, grains and cotton accounts for approximately a further 3% (Gilbert et al. 2003). Diffuse runoff from these cropping and grazing lands contributes more than 90% of nutrient loads in catchments north of Bundaberg (figure 6.16).



Cattle grazing affects downstream water quality. (Photo: DNRM)

Beef cattle grazing in the large, dry Burdekin and Fitzroy catchments has resulted in widespread erosion and nutrient loss, because cattle strip vegetation and groundcover, and loosen the soil surface by trampling. Cattle with access to waterways can also strip riparian vegetation, and defecation introduces nutrients and pathogens directly to the water.

Cropping involves intensive fertiliser and pesticide use and has resulted in substantial soil erosion. Sugarcane is the most important cultivated crop and is now harvested from 430 000 ha, primarily on the coastal plain south of the Daintree River (17°S). Although application rates of nitrogen and phosphorus fertilisers vary regionally, under average cultivation practices approximately 180 kg/ha of nitrogen fertiliser is applied annually. More than 60% of this nitrogen is lost to the atmosphere, is stored in the soil, or enters waterways through surface runoff or as groundwater. The cotton industry uses nitrogenous fertilisers at an average application rate of 150 kg/ha/year, whereas banana cultivators can apply more than 400 kg/ha/year.

Over the past 30 years, application rates of nitrogenous fertilisers have continued to increase at a rate of approximately 4000 kg/year; it is estimated that 100 000 t of nitrogen are applied annually (Furnas 2003). Although soil phosphorus concentrations are now in excess of crop requirements following many years of application, the use of phosphatic fertiliser has increased in the past four years; it is estimated that currently approximately 20 000 t of phosphorus are applied to the Great Barrier Reef catchment each year (Furnas 2003).

The sugarcane and cotton industries are major users of pesticides and herbicides. In 1996, an audit of the sugarcane industry showed that the most commonly applied herbicides were atrazine (~ 332 t), diuron (197 t), 2,4-D (142 t), glyphosate (86 t) and ametryn (76 000 kg); significant quantities of the insecticide chlorpyrifos (74 t) were also used (Hamilton and Haydon 1996).

Endosulfan is still widely used in the cotton and fruit and vegetable industries. Although the use of organochlorine pesticides was banned in the 1980s, several assessments have found significant concentrations of aldrin, lindane, DDT, dieldrin and heptachlor in sediments, highlighting their persistence.

Aquaculture

Land-based and offshore aquaculture has continued to grow, and a total area of 1088 ha is under cultivation for the farming of prawns, barramundi, crayfish and eels (table 6.16). The major pressures associated with aquaculture relate to the quantity and potentially high concentrations of nutrients contained in waste discharged into nearby waterways. Aquaculture also carries the risk of release of disease to the environment through the accidental introduction of exotic pathogens and parasites to wild fish stocks and other marine animals.



Oil tanker, Tangalooma wrecks (Photo: EPA)

Land-based and shipping industries

Heavy metals (lead, zinc, copper, cadmium, mercury, nickel and chromium) and the metalloids arsenic and selenium occur naturally in low concentrations in coastal and estuarine waters, but mining, manufacturing and agricultural industries, as well as runoff from roads that carry heavy traffic, have the potential to release increased levels of these heavy metals to adjacent waterways. The highest concentrations are found in canal estates, common in south-east Queensland; there is little evidence of elevated levels of heavy metals in other coastal areas (table 6.19).

Wastes such as oils and shipboard sewage, generated by boating and slipway activities, can affect the local marine environment around commercial and recreational port facilities. Another significant concern is the use of organotins such as tributyltin (TBT) as biocides in anti-fouling paints, commonly applied to vessels and industrial structures. Although the use of TBT anti-foulant paints was banned on vessels less than 25 m in length in 1989, there is evidence of recent TBT contamination around commercial port facilities (table 6.20).

Dredging for reclamation, sale or maintenance of port and shipping channels increases turbidity through resuspension of sediment. Over 6 million cubic metres of material are estimated to have been removed from dredging sites between July 1999 and June 2002 (table 6.11).



Oil from a leaking pipeline spread into wetlands and waterways at Lytton in March 2003. (Photo: QFRS)

Accidents resulting in the spillage of chemicals and oils can have profound effects on coastal and estuarine waters; a massive concerted effort is required to contain them and remediate the sites. In 2001–02, 96 oil spills in Queensland waters were reported to Queensland Transport (figure 6.9); the majority were around Brisbane. Significant industrial spills in the past three years included the accidental release of pesticides from an industrial plant that had caught fire into a nearby waterway at Salisbury, the release of 3000 litres of diesel fuel into Shute Harbour from a storage facility, and the release of approximately 1 500 000 litres of light crude oil in the wetlands and waterways at Lytton from a leak in an oil pipeline. The grounding of a Malaysian container ship on Sudbury Reef in the Great Barrier Reef Marine Park in late 2000 resulted in 100 times the safe level of TBT on the reef.

Condition and trends

Regional water quality condition and trends

Figure 6.18 summarises recent (1999–2002) water quality conditions in eight coastal catchments. Concentrations of the macro-nutrients nitrogen and phosphorus, water clarity, dissolved oxygen and chlorophyll *a* that were measured monthly at over 440 sites are benchmarked against national standards, or trigger values, defined in the Australian and New Zealand Water Quality Guidelines (ANZECC and ARMCANZ 2000) for the maintenance and protection of aquatic ecosystems. The water quality of a site was rated as poor if less than 20% of results complied with these standards, moderate if 20–50% of results met the standards, and good if more than 50% of sites attained the standard. As healthy aquatic ecosystems can thrive in a range of water quality conditions which may vary naturally—between water bodies (such as estuaries and coastal waters) and among regions—and may exceed the current standards, care is needed in judging whether any exceedences are the result of human activity.

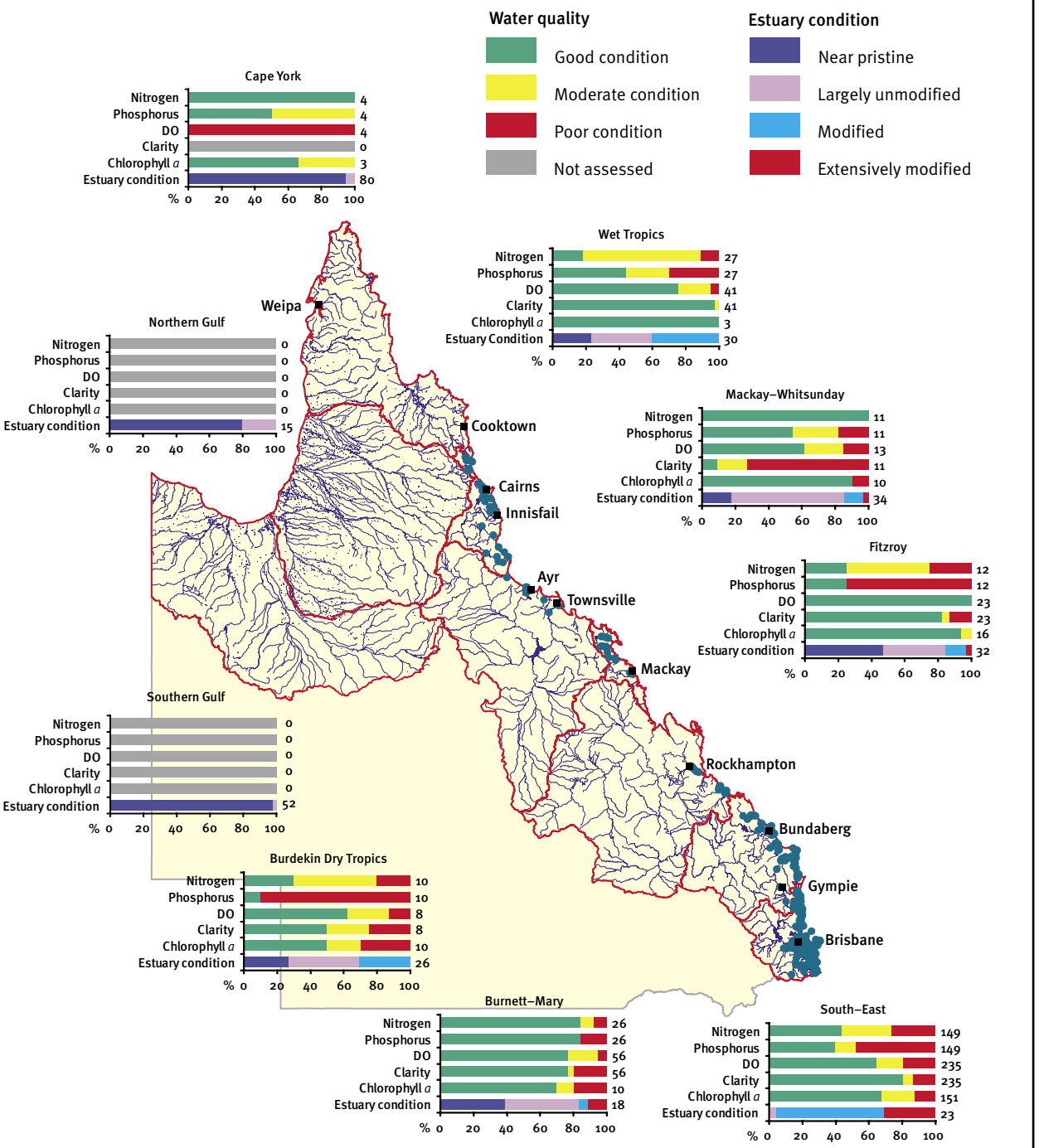
Across all sampling sites, phosphorus was the indicator that caused the greatest percentage of sites (43%) to be rated as poor; the majority of these sites were in the Burdekin Dry Tropics, Fitzroy and South East Queensland NRM regions. In more than 85% of recordings dissolved oxygen, clarity and chlorophyll *a* were rated as in either good or moderate condition. Regionally, the following observations can be made:

- no ongoing assessment of water quality has been made in the northern and southern parts of the Gulf of Carpentaria and Cape York, resulting in a significant knowledge gap;
- most waterways in the Wet Tropics are in good condition, less than 9% of sites receiving a poor rating. Nutrient concentrations often exceed guidelines in Trinity Inlet and the Barron River, although these concentrations have declined significantly in the past ten years due to improved sewage treatment;
- more than 35% of sites in the Burdekin Dry Tropics were rated as poor, phosphorus concentrations complying with objectives at only 10% of sites;
- 23% of sites in Mackay–Whitsunday were rated as poor, many of the exceedences being due to high phosphorus concentrations, low dissolved oxygen concentrations and poor clarity;
- 17% of sites in the Fitzroy were rated as poor, due mainly to high phosphorus concentrations. Chlorophyll *a* and dissolved oxygen achieved complete compliance with objectives, and water clarity did so at more than 85% of sites;
- 13% of sites in the Burnett–Mary region did not comply with environmental objectives, high phosphorus concentrations and low water clarity being the main concerns; and
- 22% of sites in South East Queensland did not comply with environmental objectives, nitrogen and phosphorus concentrations exceeding objectives on 20–40% of occasions (figure 6.18). Recent reports from several other monitoring programs conducted in south-east Queensland, the most well known being the Ecosystem Health Monitoring Program (see page 6.40), have all concluded that nitrogen, phosphorus, water clarity and dissolved oxygen concentrations are the parameters for which the greatest number of sites were rated as being in poor condition (Abal et al. 2002; Counihan et al. 2002; GCCC 2003; Ramsay et al. 2002).

A recent assessment of long-term trends of these parameters over the past ten years (EPA 2003) highlights the difficulty in discerning long-term regional trends; significant increases and decreases, notably in nutrient concentrations and water clarity, were usually confined to one or two sites on a water body, emphasising the influence of local land use practices.



A lack of continuing water quality assessment in Cape York and parts of the Gulf of Carpentaria results in a significant gap in knowledge. (Photo: L. Knight, EPA)



	NH_3	NO_x	TN	FRP	TP	Chl *a*	Turbidity	DO	pH
Tropical Australia	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(µg/L)	(NTU)	(% sat)	
Upland river	0.006	0.03	0.15	0.005	0.01	NA	15	90–120	6.0–7.5
Lowland river	0.01	0.01	0.3	0.004	0.01	5	15	85–120	6.0–8.0
Estuaries	0.015	0.03	0.25	0.005	0.02	2	20	80–120	7.0–8.5
Marine	0.01	0.008	0.1	0.005	0.015	1.4	20	90–120	8.0–8.4
South-east Australia									
Upland river	0.01	0.015	0.25	0.015	0.03	NA	25	90–110	6.5–7.5
Lowland river	0.02	0.06	0.5	0.02	0.05	5	50	85–110	6.5–8.0
Estuaries	0.015	0.015	0.3	0.015	0.03	5	20	80–110	7.0–8.5
Marine	0.015	0.005	0.12	0.01	0.025	1.5	1	90–110	8.0–8.4

Guideline values used for assessment (from ANZECC 2000)
NH_3 = ammonia nitrogen
NO_x = oxidised nitrogen
TN = total nitrogen
FRP = filterable reactive phosphorus
TP = total phosphorus
Chl *a* = chlorophyll *a*
DO = dissolved oxygen
NA = not assessed.

Figure 6.18 *Summary of regional water quality condition in coastal areas of Queensland. The regional bar graphs for nitrogen, phosphorus, dissolved oxygen, clarity and chlorophyll a show the percentage of sites (numbers of which are shown at right of each bar) classified from data collected from the most recent year of sampling as being in good condition (at least 50% of samples comply with guidelines), moderate (between 20% and 50% comply with guidelines) or poor (less than 20% comply with guidelines). The ANZECC guideline values used to benchmark these parameters are shown in the inset. The estuary condition shown in each region is taken from the NLWRA, which used data and expert opinion of a number of factors to classify estuaries as either near pristine, largely unmodified, modified or extensively modified.*
Source: EPA

Bioaccumulation of contaminants

While the accumulation of heavy metals, pesticides and derivative chemicals in biota resident in waterways has been assessed in specific areas, no ongoing statewide program is in place. Tables 6.19 and 6.20 show the ranges of organic contaminants and metals reported in various studies involving marine biota, including oysters, fish and crabs, and sediments in the period 1998–2003 for southern, central and northern regions. Metal concentrations are benchmarked against the Australian Food Standards Code (ANZFA 1996).

Canals are a common feature of coastal residential areas in south-east Queensland. The metal burden (zinc, copper and cadmium) in bivalves collected from these canals is distinctly greater than in those collected from other natural water bodies because of inputs from stormwater and intensive boating activity. Average concentrations of zinc, arsenic and lead in oysters, prawns, crab and fish complied with the Australian Food Standards Code in all regions. Selenium concentrations in mud crabs exceeded the standard in all three regions, and did so also in the few oyster, prawn and fish samples collected in south-east Queensland (table 6.19).

The food standard for copper in prawns was exceeded occasionally in samples collected from south-east Queensland, as was the cadmium standard for oysters sampled from canals and in edible and non-edible crabs collected from south-east and central Queensland.





Metal concentrations in marine biota, including oysters, are tested in coastal waterways of Queensland. (Photos: M. Mortimer, EPA)

Table 6.19 Range of metal concentrations (mg/kg) in marine biota grouped according to Southern, Central and Northern EPA regions

Biota	Metal or metalloid (mg/kg)						References
	Selenium	Zinc	Copper	Cadmium	Arsenic	Lead	
Southern Region							
Fish	0.2–2.86 (28)	2.8–62.3 (28)	0.15–4.3 (28)	<0.001–0.009 (4)	–	–	1, 9
Crabs (edible)	0.51–1.33 (5)	34.8–90.0	7.6–36	0.01–0.09	1.53–3.62	0.01–0.03	8
Crabs (non-edible)	1.78–4.14 (12)	68.8–98.8 (12)	62.5–110 (12)	0.11–0.887 (12)	4.6–16.3 (12)	0.83–6.51 (12)	8
Prawns	0.4–1.09 (12)	11.7–66.8 (12)	4.1–25 (12)	0.1–0.5 (2)	–	–	9
Bivalves (natural)	0.47–1.14 (15)	11.6–278 (15)	0.89–28.7 (15)	0.12–1.02 (14)	–	–	2, 9
Bivalves (canals)	0.01–1.2 (8)	130–56 (8)	21–110 (8)	nd–3.0 (8)	1.5–4.5 (8)	0.011–0.07 (8)	3, 4, 5, 6, 7
Seagrass	–	105–391	4.0–8.5	–	–	–	10
Central Region							
Crabs (edible)	1.88 (1)	34.4–50.4 (2)	3.32–39.27(2)	<0.02–0.02 (2)	4.05–9.49 (2)	<0.02–0.02 (2)	8
Crabs (non-edible)	1.94–4.38 (5)	56–160	66.2–245	0.074–0.84	8.19–18.3	1.32–26.7	8
Seagrass	–	65–235	5.0–22.9	–	–	–	10
Northern Region							
Crabs (non-edible)	3.12–3.78 (4)	79–124	72.5–102	<0.01	14.9–18.5	1.32–3.22	8

Note: The numbers in parentheses are the numbers of samples. Measurements were made on composite tissue samples of biota, except for edible crabs, where muscle tissue was extracted. Data were standardised to wet weight except for non-edible crabs and seagrass, which are normalised to dry weight. nd = not detected. References: 1 = Batley et al. 2000; 2 = EPA Qld Waterways Database; 3 = Kanduri et al. 2003; 4 = Keys and Mortimer 2001, 2002a, 2002b; 5 = Keys and Mortimer 2003; 6 = Keys et al. 2002; 7 = Keys et al. 2003; 8 = Mortimer 2000; 9 = Müller et al. 1999; 10 = Prange and Dennison 2000.

Source: EPA

The highest concentrations of the commonly used herbicides atrazine and diuron have been detected in northern and central sediments. Atrazine was restricted to some Wet Tropics waterways, but diuron was more widespread along the Queensland coast (Haynes et al. 2000a), and was observed in concentrations high enough to inhibit the growth of seagrass communities (Haynes et al. 2000b). Banned organochlorine pesticides, including DDT, lindane and dieldrin, persist in sediments along the Queensland coast, in areas adjacent to agricultural catchments (Mortimer 2000; Haynes et al. 2000a). Dieldrin persists in soil, sediment and biota at levels sometimes exceeding ANZECC standards (Mortimer 2000). Dioxin contamination is widespread along the Queensland coast, high levels (relative to international criteria) being detected in seagrass, dugongs and inshore marine sediments (Gaus 2002).

In 2001, a national survey of ports and marinas revealed that TBT contamination in Queensland had declined significantly in areas associated with recreational vessel traffic. Some decreases in TBT concentrations in and around commercial port facilities have occurred, but there is still evidence of recent contamination of waterways close to commercial vessel repair facilities, notably on the Maroochy and Brisbane rivers, and at Cairns. Most of these sources have been identified and regulatory agencies have worked with industry to eliminate discharges through remedial actions including on-site treatment, no discharge to rivers, and removal of existing contaminated sediments.

Table 6.20 Range of pesticides and TBT concentrations (µg/kg) in marine organisms and sediments grouped according to Southern, Central and Northern EPA regions observed in studies in the period 1998–2003

Biota	Pesticide (µg/kg)								References
	Dieldrin	Other persistent organo-chlorines	Chlor-pyrifos	Bifenthrin	PCBs	Total herbicide (atrazine + diuron)	Dioxins	TBT (µg/kg)	
Southern Region									
Dugongs	–	–	–	–	–	–	0.047–0.182 (2)	–	2
Fish	1.5–18 (4)	0.2–56 (5)	–	–	–	–	–	–	1
Crabs (edible)	0.026–0.66 (4)	0.018–2.8	–	–	–	–	–	–	10
Crabs (non-edible)	0.21–1.6 (10)	<0.05–2.25	–	–	–	–	–	–	10
Prawns	0.4–2.45 (2)	1.1–4.4 (3)	–	–	–	-	–	–	1
Bivalves	<0.001–6.2 (9)	nd–8.8	0.001–16	nd–120	nd–4.3	-	–	11–30 (2)	4, 5, 6, 7, 8, 11, 12
Seagrass	–	<1.0 (2)	<1.0 (2)	–	<50 (2)	<1.0–2.2 (2)	0.198–0.28 (2)	–	2, 3
Sediments	–	<1.0 (2)	<1.0 (2)	–	<50 (2)	<1.0 (2)	0.26–0.51 (2)	5–10500 (2)	2, 3, 12
Central Region									
Dugongs	–	–	–	–	–	–	0.075–1.85 (5)	–	2
Crabs (edible)	<0.03 (1)	<0.03 (2)	–	–	–	–	–	–	10
Crabs (non-edible)	0.069–5.5 (5)	0.027–2.2	–	–	–	–	–	–	10
Bivalves	–	–	–	–	–	–	–	14–21 (2)	12
Seagrass	–	<1.0 (9)	<1.0 (9)	–	<50 v	<1.0–1.3 (9)	0.7–16 (3)	–	2, 3
Sediments	<0.05 (6)	<1.15–1.21 (15)	<1.0 (9)	–	<50 (9)	nd–<2.6 (20)	0.42–21 (4)	2.9–3.5 (2)	2, 3, 9, 12
Northern Region									
Dugongs	–	–	–	–	–	–	0.016–0.56 (7)	–	2
Crabs (non-edible)	0.043–0.84 (4)	0.043–0.21	–	–	–	–	–	–	9
Bivalves	–	–	–	–	–	–	–	44 (1)	11
Seagrass	–	<1.0 (5)	<1.0 (5)	–	<50 (5)	<1.0 (5)	–	–	2
Sediments	<0.05–0.37 (19)	<1.15–1.36 (24)	<1.0 (5)	–	<50 (5)	<1.2–11.2 (24)	0.056–1.6 (8)	140 (1)	2, 3, 12

Note: The numbers in parentheses are the numbers of samples. Measurements were made on composite tissue samples of biota except for edible crabs, where muscle tissue was extracted. Data are standardised to wet weight except for seagrass and sediment, which were normalised to dry weight, dugong to lipid, and TBT to either 1% lipid or total organic carbon. nd = not detected. References: 1 = Batley et al. 2000; 2 = Gaus 2002; 3 = Haynes et al. 2000a, 2000b; 4 = Kanduri et al. 2003; 5 = Keys and Mortimer 2001, 2002a, 2002b; 6 = Keys and Mortimer 2003; 7 = Keys et al. 2002; 8 = Keys et al. 2003; 9 = McMahon et al. 2003; 10 = Mortimer 2000; 11 = Mortimer and Cox 1998; 12 = NHT TBT project.

Source: EPA

Recreational water quality

There has been a general improvement in recreational water quality at both beach and river sites in south-east Queensland, river sites increasing from 44% to 83% compliance (figure 6.19). Recreational water quality monitoring of popular rivers and beaches in south-east Queensland over the summer months for the past five years found that 35 of 46 beaches complied with national guidelines (ANZECC and ARMCANZ 2000) on all occasions and only two sites complied on less than 67% of occasions. Of the 18 rivers sampled, only two complied fully, while 10 complied on less than 68% of occasions.

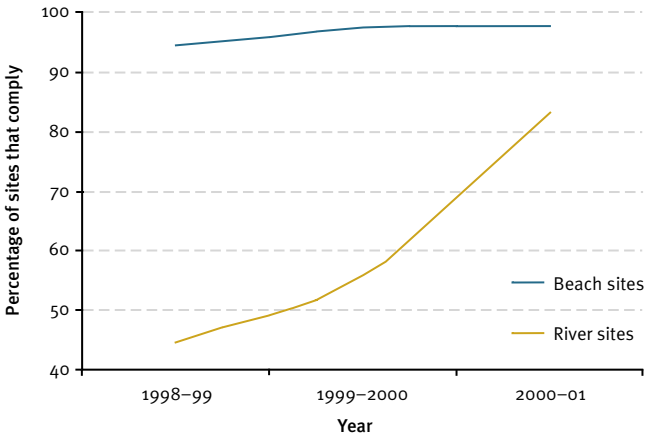


Figure 6.19 *Recreational water quality compliance for beach and river sites in south-east Queensland from 1998 to 2001. Medians and 80th percentiles were compared with national guidelines.*
Source: EPA

Aquatic ecosystem condition

An audit of the condition of the nation's estuaries rated the condition of more than 82% of the 300 or so estuaries in Queensland as good (NLWRA 2002). The majority of these estuaries are in the Gulf Country. South-east Queensland, followed by the Burnett–Mary, has the highest proportion of estuaries rated in poor or moderate condition (see summary table, page 6.43).

In south-east Queensland, the Ecosystem Health Monitoring Program summarises the condition of Moreton Bay (see page 6.41). This monitoring program results in an annual report card and report that integrate a number of physico-chemical and biological indicators to assess the condition of regions within Moreton Bay and its estuaries. Several improvements in ecosystem health between 1998–99 and 2001–02 were attributed to improvements to a number of sewage treatment plants in the region.

One of the greatest concerns is the potential impact of increased sediment and nutrient loads on the nearshore regions of the Great Barrier Reef (GBR). Areas of the GBR that have been specifically identified as being at high risk of impact from terrestrial runoff are the Port Douglas to Hinchinbrook and Whitsunday to Mackay regions. Several reports conclude that although there is little evidence that there has been any serious impact on the World Heritage values of the GBR, changes in nutrient and sediment loading from inappropriate and unsustainable land use practices call for a precautionary approach to reduce catchment runoff, to be implemented through a reef protection plan.

Long-term monitoring of phytoplankton chlorophyll *a* concentrations has been undertaken since 1992 at 86 stations in the Great Barrier Reef lagoon. Recent analysis of the data showed that strong regional patterns in chlorophyll *a* are evident and although no significant long-term trends could be discerned, regional patterns may be closely correlated with the influence of El Niño Southern Oscillation (ENSO) or river discharge volumes. Chlorophyll *a* concentrations in inshore areas adjacent to catchments that are highly developed for agricultural and urban uses are more than double the mean concentrations in inshore areas adjacent to Cape York catchments in the north, which are largely undeveloped (Brodie et al. 2003).

Algal blooms are often natural events, but excessive nutrient levels sometimes lead to unwanted nuisance or harmful algal blooms with potentially significant and costly health, recreational and commercial repercussions. Excessive chlorophyll *a* concentrations occurring in water bodies can indicate the presence of algal blooms and, indirectly, nutrient status. In the past five years, two potentially toxic algae occurring naturally throughout parts of Queensland have required dedicated responses to understand their occurrence and to manage their impacts. *Lyngbya majuscula* (Lyngbya), a benthic blue-green algae, occurs from Moreton Bay to Hinchinbrook Channel (see 'Biodiversity'). State and local governments have responded to Lyngbya blooms in Moreton Bay by developing a Lyngbya Management Strategy (MBWCP 2002), including the development of a contingency plan and funding for scientific research into the cause of the blooms. The dinoflagellate *Pfiesteria piscicida* was found in low concentrations in south-east Queensland waterways in 2002, but there is no evidence that Pfiesteria is having any impact on human health or fish populations in Australia.

Fish kills can result from poor water quality conditions including low dissolved oxygen, blooms of toxic plankton and chemical contamination and are often more common following significant rainfall events. No comprehensive reporting of fish kills in Queensland coastal water has been done in the reporting period. The recently implemented Queensland Fish-kill database (www.epa.qld.gov.au) reports 71 fish kills in 2002 and a further 26 to July 2003. More than 40% of these incidents occurred in south-east Queensland, notably around the Gold Coast region, and in the Northern region, where in 2002 a total of approximately 150 000 fish were found dead in three separate incidents in the Cairns and Townsville regions. On more than 25% of occasions mullet and bony bream were reported as the key species, and the causes of these fish kills were most commonly attributed to low dissolved oxygen (38%), chemical contamination (21%) and trawl or fishing bycatch (15%).

Responses

Integrating coastal and catchment management

The State Coastal Management Plan—Queensland's Coastal Policy (EPA 2001) provides policy direction to manage stormwater runoff (quality and quantity) in accordance with best practice to ensure that the environmental values of estuaries and coastal areas are protected.

The Reef Water Quality Protection Plan is a joint initiative of the Queensland and Commonwealth governments to implement actions in catchments to mitigate the potential risk to the Great Barrier Reef by halting and reversing the decline in quality of water entering the Reef. Building on government, industry and community-based programs, the plan identifies a broad mix of 65 actions, ranging from regulatory and planning frameworks to self-management and economic incentives and extension, that support progressive improvement in land use practices.

A major initiative in water quality management in Queensland has been the development of the South East Queensland Regional Water Quality Management Strategy. This is a comprehensive, integrated water quality plan for south-east Queensland waterways and catchments. It provides the framework for future management actions that are workable, practical and affordable. The strategy has been developed in light of the findings from detailed baseline monitoring and modelling of water quality indicators.

Setting targets, monitoring and assessment

The setting of environmental values and water quality objectives for waters is a requirement under the National Water Quality Management Strategy and is mirrored in Queensland's Water EPP. Areas in Queensland for which environmental values and water quality objectives have been or are being set include south-east Queensland, the Condamine-Balonne catchment and the Trinity Inlet and Mossman-Daintree catchments. It is intended that setting of environmental values in other areas of Queensland will be aligned with both the water resource planning process and the target-setting regional processes that will occur as part of the National Action Plan for Salinity and Water Quality.

A range of monitoring programs is conducted throughout Queensland's coastal environment by the state and local governments, community groups, universities and other research organisations:

- the latest summary of monitoring in the Great Barrier Reef World Heritage Area lists a total of 52 monitoring programs looking at water quality and aquatic communities in the region (Harriot et al. 2002);
- a collaborative water quality monitoring program in south-east Queensland now covers more than 360 sites across a region extending from the Noosa River south to the New South Wales border;
- Waterwatch is a significant community monitoring program involving close to 2500 individuals in monitoring Queensland's aquatic environment; and
- the Queensland Government is currently reviewing and redesigning its monitoring programs to better meet current and future needs for water quality information. The review will also suggest how both regional and community monitoring programs could fit into an overall framework of monitoring in Queensland.

Working with community and industry to reduce and recycle wastewater contaminants

The National Action Plan for Salinity and Water Quality is a major Commonwealth and state government initiative to prevent, stabilise and reverse trends in salinity and improve water quality in Queensland. It will provide funding over seven years for priority areas including the Fitzroy and Burdekin River catchments and the Lockyer, Burnett and Mary River catchments. Regional community-based groups are funded on the basis of an integrated natural resource management plan that specifies targets for resource condition and management actions.

The significant reductions in point source nutrient discharges achieved in the past five years are the result of well-directed collaborative partnerships, including the Moreton Bay Waterways and Catchments Partnership, and the production of guiding documents such as management plans and the development of operational guidelines for aquatic discharges. In south-east Queensland significant investments by local councils to upgrade a number of the larger STPs have resulted in an overall reduction of almost 35% in the total nitrogen load since 1999. Further upgrades to sewage treatment infrastructure will reduce the pressure of increased nutrient loads from point source discharges.

The Queensland Water Recycling Strategy, released in 2001, provides a framework to encourage the adoption of sustainable and cost-effective water recycling by providing a set of guiding principles, policy positions on uses and sources of recycled water, and action plans with objectives and targets to guide public and private sector initiatives.

The management of urban stormwater is recognised as one of the key issues for maintaining and improving water quality in urban areas. The Water EPP requires local governments with an urban stormwater system to develop an urban stormwater quality management plan. Many local governments in Queensland have developed and are now implementing these plans. A key part of the implementation is installation of stormwater quality improvement devices (SQIDs), ranging from simple litter traps and gully pit baskets to larger end-of-pipe structures, to reduce the amount of sediment and litter entering waterways. Since 1999, over $15 million has been expended on SQIDs in the urban areas of the state's south-east.

A number of on-farm best management programs such as COMPASS (Combining Profitability and Sustainability in Sugar) for the sugar industry and the Best Management Practice for the Cotton Industry have been implemented to encourage sustainable primary production practices. ChemCollect was a free collection and destruction scheme for unwanted agricultural and veterinary chemicals, which ran for three years and was completed in August 2002. It enabled more than 3000 primary producers to safely rid their properties of some 400 tonnes of unwanted chemicals, representing a direct cost benefit to the community of between $11.3 and $14.0 million.

Case study: Bremer River carbon inputs

Historical commentary on the Bremer River describes a once-pristine waterway that, over time, deteriorated because of pressures from land use in the surrounding catchment. Improvements in management practices in recent decades have resulted in reduced pollution, particularly by acutely dangerous pollutants such as toxins and heavy metals.

Unfortunately, the more insidious and chronic pollutants such as nutrients and sediments still have a major impact on the river. This poor condition has been summarised in an annual report card, which rated the Bremer as an 'F' (fail) from 2000 to 2002. The causes of this condition have been difficult to identify. Figure 6.20 illustrates the key sources of pollution in the Bremer catchment.

A particularly important issue for the Bremer is repeated occurrences of low dissolved oxygen. A recent study by the Cooperative Research Centre for Coastal Zone, Estuary and Waterway Management (Coastal CRC) indicated that organic carbon is an important contaminant, particularly from runoff in wet periods. Carbon is present naturally in all rivers and is the primary food and energy source of most bacteria. Bacterial depletion of oxygen is the major cause of fish kills. Bacterial growth in the Bremer, unlike most rivers, remains high in dry times, pointing to a constant background source of carbon. This constant source maintains bacterial growth, causing repeated depletion of dissolved oxygen, and is one of the main reasons the Bremer estuary was failed in 2002.

This research has catalysed a collaborative audit of the Bremer catchment involving the EPA, Boonah Shire Council, Ipswich City Council, the Coastal CRC, the Moreton Bay Waterways and Catchments Partnership and the Bremer Catchment Association. The focus is on developing solutions for priority issues and identifying ongoing management options that will ensure improvements in the Bremer River, making it a sustainable working river in the long term.

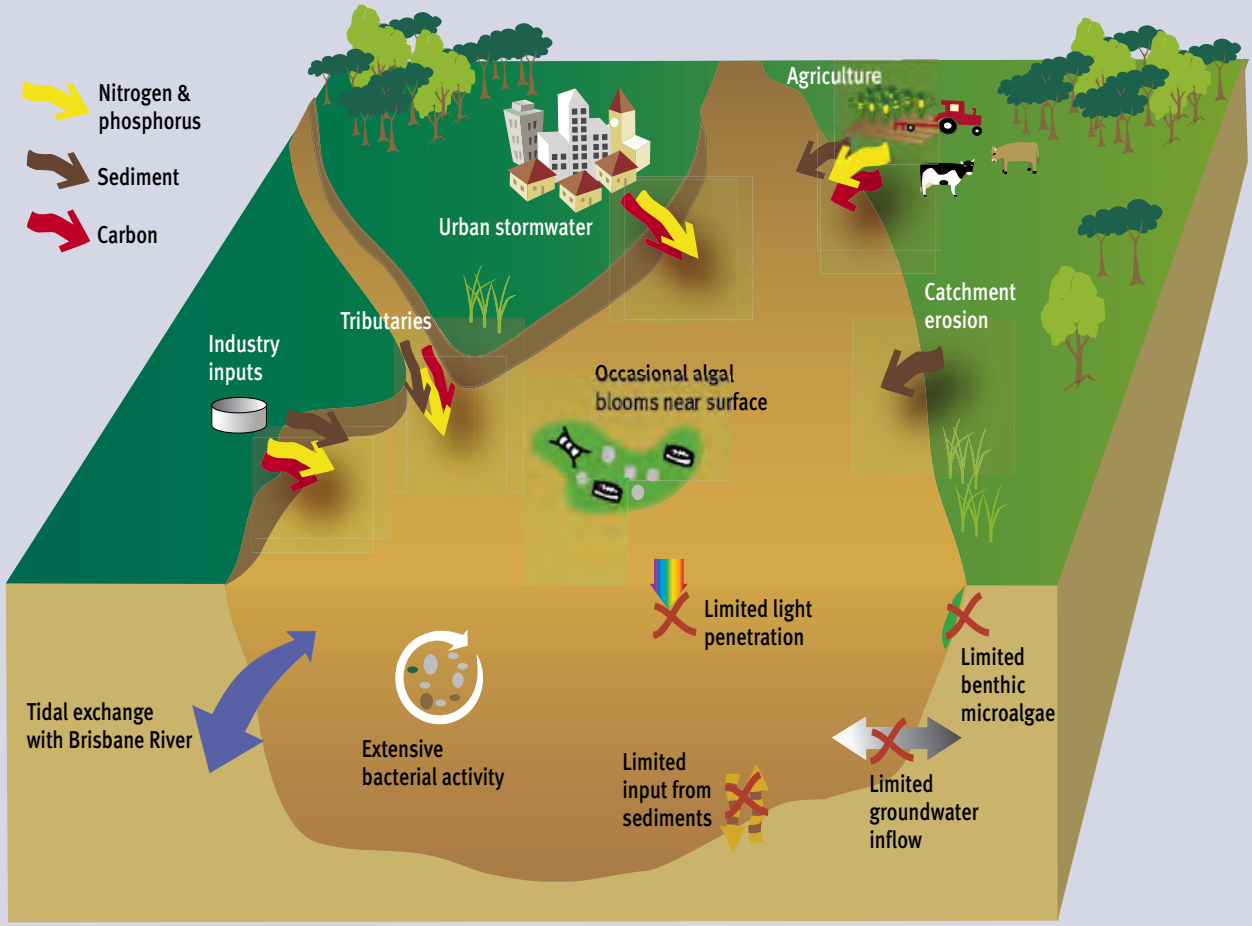


Figure 6.20 *Key issues and drivers in the Bremer catchment*
Source: Coastal CRC

Case study: Managing acid sulfate soils

During the past decade acid sulfate soils have been recognised as one of the most important environmental issues resulting from drainage in low-lying coastal areas (figure 6.21). Past expansion of the sugar industry and drainage schemes on coastal lowlands have led to unintended offsite impacts that have lasted for decades. The expansion of sugarcane into the East Trinity area near Cairns collapsed because of acid sulfate soil problems. Issues associated with acid sulfate soils include major fish kills and outbreaks of red spot disease in fish, and the increased incidence of disease-carrying, acid-tolerant mosquitoes. The acid can also attack concrete, steel and road infrastructure (bridges, bitumen, pipes and foundations). Impacts can persist for decades.

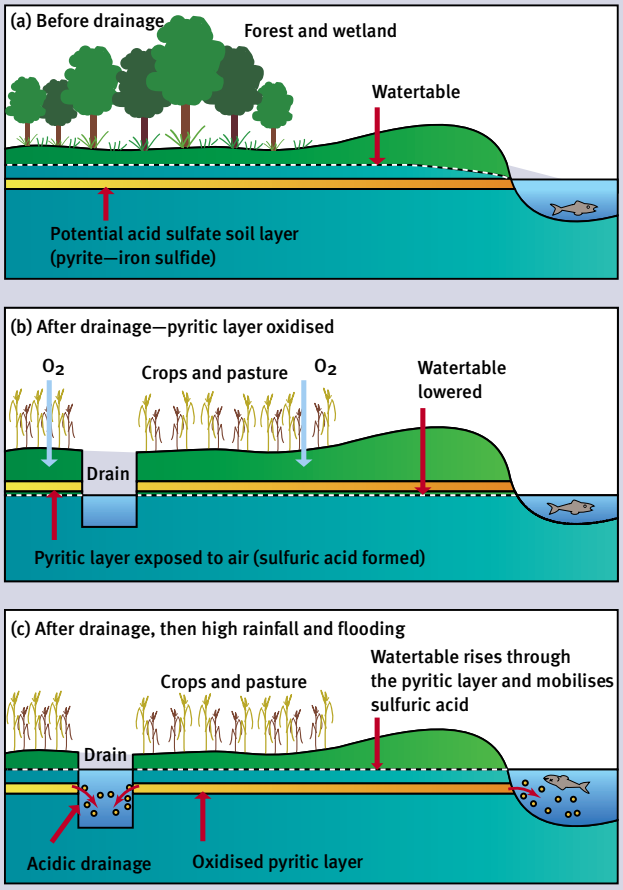


Figure 6.21 *Potential acid sulfate soils do not harm the environment when covered by water (a), but when drained and exposed to air (b) they react following rainfall to release sulfuric acid into the drainage system (c), affecting aquatic life.*
Source: DNRM

Acid sulfate soils are found in low-lying areas generally below 5 m Australian Height Datum along the Queensland coast (figure 6.22). Acid sulfate soils along the Queensland coast cover an estimated 2.3 million hectares.

No statewide statistics on the total area of disturbed acid sulfate soils or the number of hotspots causing acidification of waterways are available. The known acidified area of disturbed acid sulfate soils in south-east Queensland is 8219 ha, representing 11% of mapped acid sulfate soils (78 000 ha).

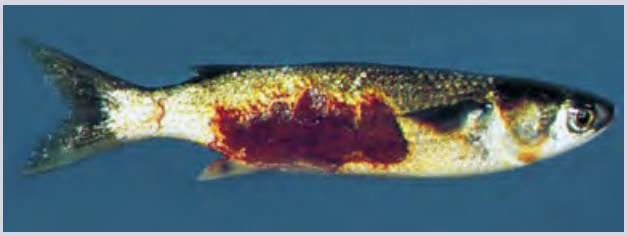


Figure 6.22 *Distribution of acid sulfate soils along the Queensland coast*
Source: DNRM

Major growth areas where acid sulfate soils management has been required include developments at Cairns, Cardwell, Townsville, Proserpine, Yeppoon, Gladstone, the Sunshine Coast, Redcliffe, Bribie Island, and the Gold Coast. Eighty-nine licences with acid sulfate soil conditions were issued in south-east Queensland between 1995 and 2001. Further sugarcane expansion onto coastal lowlands also carries a risk of draining acid sulfate soils. Another pressure has emerged with the development of an aquaculture industry involving the construction of ponds and channels. In south-east Queensland, 14 currently active EPA licences (with acid sulfate soil conditions) apply to aquaculture.

Planning policies and regulations launched by the Queensland Government in 2002 require best practice management of acid sulfate soils and are reducing the risk of environmental damage and future remediation costs. The Queensland Acid Sulfate Soils Management Advisory Committee (QASSMAC) represents the urban development, sugar and fishing industries, Landcare and conservation groups, local governments and affected state government agencies. In 2002, the Queensland Government released *SPP 2/02: Planning and Managing Development Involving Acid Sulfate Soils*. QASSMAC, in collaboration with government agencies, has also released soil management guidelines for acid sulfate soils.

Case study: Managing acid sulfate soils *(continued)*



Red spot disease in fish is an indicator of acid sulfate soil problems. (Photo: D. Callinan, NSW Agriculture)

SPP 2/02 and the guidelines for planning and managing development involving acid sulfate soils cover best practice methods. The number of acid sulfate soil management plans required in development applications has grown dramatically since 1994 and industry-based guidelines or codes of practice have also been developed to deal specifically with acid sulfate soils. For example, DPI has developed Fish Habitat Codes of Practice for use with Strategic Permits issued under section 51 of the *Fisheries Act 1994*.

Indicator	FN	N	NW	MK	F	GN	WB	MN	BN
Coastal population growth, 1991–2002	▲	▲	▲	▲	▲	▲	▲	▲	▲
Area of land extremely acidified by acid sulfate soils (ha)	P	P	X	P	P	P	P	8219*	P
Number of 'hotspot' areas causing acidified waterways	P	P	X	?	P	?	P	P	?
Number of currently active EPA licences with acid sulfate soil conditions	X	X	X	X	X	X	– o	▲ 48	▲ 41

Key to Statistical Divisions (regions): FN = Far North; N = Northern; NW = North West; MK = Mackay; F = Fitzroy; GN = Gladstone; WB = Wide Bay–Burnett; MN = Moreton; BN = Brisbane

Key to condition for coastal population growth:
- Low growth (<20 000)
- Moderate growth (20 000–60 000)
- High growth (>60 000)
- ▲ Increasing pressure

Key to condition:
- Good progress
- Moderate progress
- Poor progress
- Not rated
- 41 Number of active licences

Key to trend:
- ▲ Increasing
- ? Not clear
- X Not assessed
- – No change
- P Present but extent unknown
- * Underestimate, based on available mapping

Case study: Ecosystem Health Monitoring Program

The Ecosystem Health Monitoring Program (EHMP) is an environmental monitoring program established by the Moreton Bay Waterways and Catchments Partnership with the aim of assessing the effectiveness of management actions. EHMP is a collaborative program between local, state and Commonwealth government agencies, universities and CSIRO.

EHMP consists of a freshwater component and a marine and estuarine component. These components aim to assess ecosystem health in south-east Queensland through the use of a range of ecosystem health indicators. Over 240 sites are monitored monthly for the marine and estuarine component, and 120 sites are assessed twice a year for the freshwater component.



Figure 6.23 *2002 report card for the Ecosystem Health Monitoring Program*
Source: MBWCP

An effective communication tool, such as the annual report card, rates the health of the region's waterways from A (excellent condition) to F (fail). Report cards help to highlight changes in regions and are useful in communicating monitoring information to the community.

Outputs such as processed nitrogen mapping help assess the effectiveness of management actions (the predominant source of processed nitrogen is sewage). The most prominent processed nitrogen plumes of Moreton Bay occurred in Bramble Bay. Over the past four years the size and intensity of processed nitrogen plumes in Bramble Bay have decreased significantly. It is possible that this decrease is related to upgrades to a number of wastewater treatment plants in the region.

Case study: Conceptual understanding of sediment and nutrient processing in the Fitzroy River and estuary

The Great Barrier Reef Water Quality Protection Plan has identified reduction in sediment and nutrient inputs from coastal Queensland catchments as its primary objective. Regional bodies will develop plans and investment strategies to determine the most effective management actions to achieve these reductions.

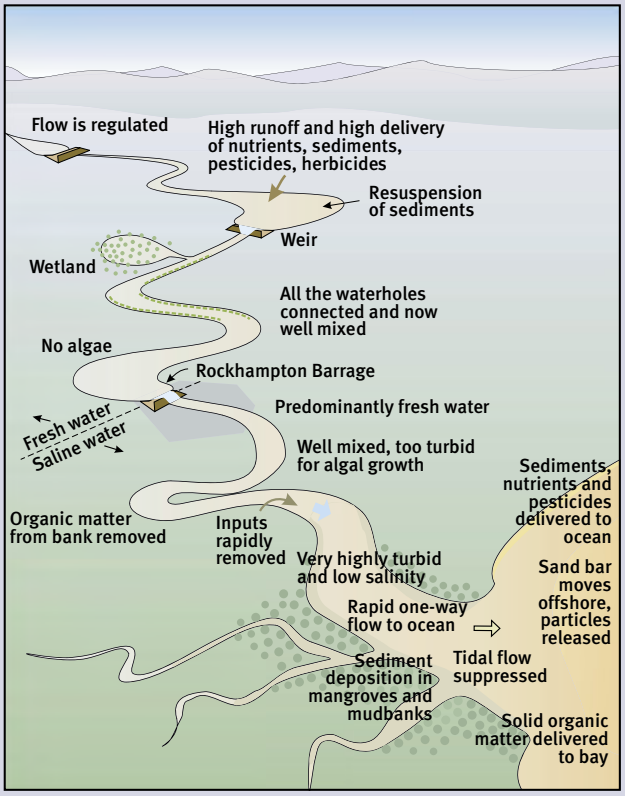


Figure 6.24(a) *High flow model for the Fitzroy River*
Source: CSIRO Land and Water

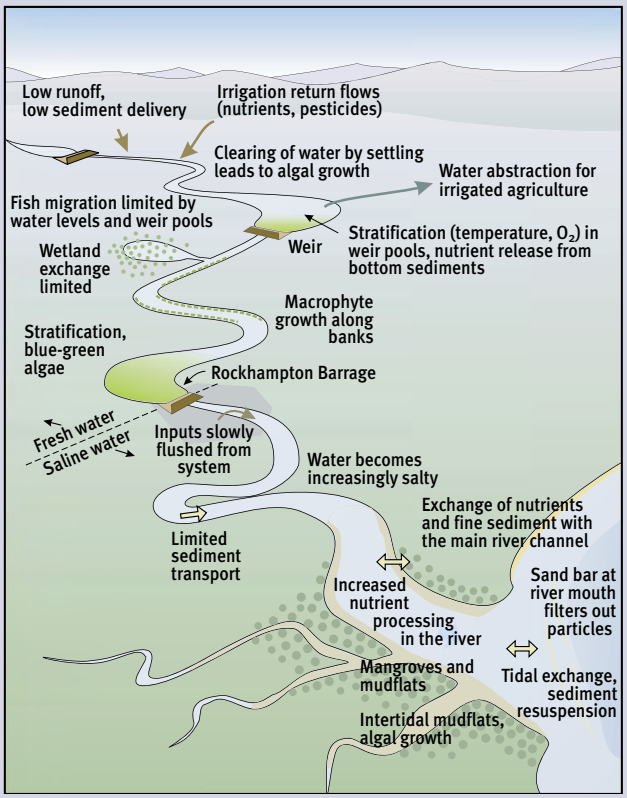


Figure 6.24(b) *Low flow model for the Fitzroy River*
Source: CSIRO Land and Water

A major issue in assessing alternative management strategies is understanding what happens to the nutrients and sediments that are washed off the catchment as they move through the rivers and estuaries and then out into the Great Barrier Reef lagoon. For the past three years, the Coastal CRC has been studying the instream processing of these sediments and nutrients, especially in the Fitzroy estuary between the barrage at Rockhampton and the mouth of the river 60 km downstream, and has developed a more complete understanding of them. The processes are highly dependent on the freshwater flows in the system: major transport and relocation of sediments occur during high flows, and more localised instream processing occurs during medium and low flows. During periods of low freshwater flows, inputs of nutrients into the estuary from the three sewage treatment plants at Rockhampton have a significant effect on water chemistry. Also, because of appreciable tidal velocities in the lower estuary, sediments are resuspended during each tidal cycle (figures 6.24(a) and (b)).

Research in the next three years will focus on a fuller understanding of the processing of sediments and nutrients in the estuary, and especially on how these move from the mouth of the river into Keppel Bay and offshore to the Great Barrier Reef lagoon.

This research will help the Fitzroy stakeholders develop and refine sediment and nutrient reduction management actions in their integrated natural resource management plan.

Indicator	Type	Source	NRM regions								
			Southern Gulf	Northern Gulf	Cape York	Wet Tropics	Burdekin Dry Tropics	Mackay–Whitsunday	Fitzroy	Burnett–Mary	South East
Total annual coastal discharges per region (tonnes/year)	Nitrogen	NLWRA/EPA	X	X	8 577	8 543	3 917	2 699	2 574	2 534	4 919
	Phosphorus	NLWRA/EPA	X	X	1 364	1 693	792	591	486	319	1 288
	Sediment	NLWRA/EPA	X	X	3 703 566	1 552 675	3 266 483	996 826	2 902 345	1 193 910	530 474
Total annual discharge volume of licensed discharges			X	X	X	X	X	X	X	X	X
Percentage of area of road (impervious surfaces) in each region		EPA/WBM	0.09	0.07	X	0.43	0.16	0.55	0.22	0.53	1.31
Number of marine pollution incidents			X	X	X	X	X	X	X	X	X
Regional water quality condition			X	X	X						
Regional estuarine condition											
Number of catchments with specific water quality objectives and environmental values			X	X	X	1	X	X	X	X	X
Number of urban stormwater plans			X	X	X	X	X	X	X	X	X

Note: X = not assessed

Pie chart legend:

Good

Moderate

Poor

Coastal habitats and biodiversity

Summary

Knowledge of Queensland's habitats and biodiversity continues to grow, although gaps remain, particularly in knowledge of the coastal zone of Cape York and the Gulf of Carpentaria. There is increased knowledge of the extent of seagrasses, mangroves and saltmarsh in Queensland, more detailed mapping of the biodiversity of the Great Barrier Reef, along with monitoring of coral cover, and growing knowledge of the species diversity of the marine environment. However, trends in habitat and biodiversity are often difficult to establish, because either only baseline studies have been conducted or the design of studies has made comparisons difficult.



Mangroves at low tide (Photo: EPA)

Data show that over the past four years the threats posed by introduced plants, the crown-of thorns starfish and the toxic cyanobacteria Lyngbya have grown. New evidence shows that the dugong has suffered a serious long-term decline, although the population appears to have stabilised. Additionally, if the coral bleaching episode of 2002 is any indication, the threat associated with climate change presents a significant challenge. On the other hand, the recovery of the humpback whale population shows that management practices can sometimes reverse previous damage. Developments in the protection of habitat, control of introduced species and changes to practices by industries that have impacts on coastal and marine environments have contributed to the regulation of pressures, but more is required. The development of suitable responses is, in some cases, hampered by lack of suitable data, and the design, coordination and resourcing of data collection and analysis require attention. Only with suitable programs of monitoring and research will it be possible to assess the effectiveness of current responses and develop new responses to the continuing threats to Queensland's biodiversity.

Coordination of the development of protection measures by various agencies also requires consideration, as a range of departments and agencies across different levels of government take a role in environmental management. State–Commonwealth cooperation in dealing with water quality issues on the Great Barrier Reef is a welcome development.



New evidence suggests that the dugong population has stabilised. (Photo: GBRMPA)

While steady improvements in protective measures for habitats and biodiversity have been made since 1999, data suggest that they are not yet sufficient. The adequacy of existing protective legislation may depend on increased allocation of resources dedicated to its implementation. The growing pressures present challenges that will require innovation to adequately protect Queensland's marine and coastal biodiversity.

Description

Queensland's coastal zone supports an enormous range of life of world significance. It is a series of highly intricate ecosystems noted for their rich species diversity, particularly within the two World Heritage Areas, the Wet Tropics and the Great Barrier Reef. The coastal zone supports a number of iconic species, including six of the world's seven species of marine turtles, the humpback whale, dolphins and dugongs, while habitat adjoining the coast supports a number of other vulnerable and endangered species, including the mahogany glider and the southern cassowary. The coastal zone also contains the bulk of Queensland's population, which places significant pressure on coastal habitats. Growing pressures on the environment present challenges that will require innovation to adequately protect Queensland's marine and coastal biodiversity.



Queensland's coastal zone supports six of the world's seven species of marine turtles. (Photo: EPA)

Pressures

Coastal habitat and biodiversity are subject to pressures arising from direct human activity, such as plant disturbance and removal associated with building and engineering works, and the accidental or deliberate killing of species, resulting from actions such as the release of toxic materials, fishing, roadkill, hunting and collecting. Maritime transport also has impacts on coastal ecology through pollution incidents, poor mooring practices, and the release of contaminants and marine pests. In addition, coastal ecosystems continue to be altered as a result of the impacts of exotic and displaced species such as lantana, rubber vine and feral pigs.



*Coastal ecosystems are altered through the impacts of exotic and displaced species such as rubber vine (*Cryptostegia grandiflora*). (Photo: EPA)*

Pressures also arise from human activity far from the coast. Sediment runoff resulting from unsustainable agricultural and mining practices and contamination from point source discharges in coastal catchments present threats. Perhaps the most profound of these more general pressures results from global warming, which has the potential to significantly disrupt ecological processes occurring on the Great Barrier Reef, in the Wet Tropics and in significant wetlands.

A number of pressures on coastal habitats and biodiversity are discussed in Chapter 7, 'Biodiversity', and in other sections of this chapter, particularly 'Coastal resource use and development' and 'Coastal water quality'.

Disturbance of coastal and marine habitat

Increasing activity associated with growth in population and exploitation of coastal resources is the main direct pressure on coastal habitats and biodiversity. Disturbance of habitat increases pressure on a number of threatened and vulnerable species, such as the mahogany glider and the cassowary.

In key areas of the state, coastal strip development is placing increasing pressure on specific coastal habitats (figure 6.6). Protected areas in the coastal zone are notably small and fragmented lands. Clearing for urban development is discussed in 'Coastal resource use and development'.



Pressures on the coastal zone can disturb the habitats of threatened and vulnerable species, including the mahogany glider. (Photo: Queensland Museum)

Marine plant removal

Removal and disturbance of marine plants are regulated by the *Fisheries Act 1994*; the number of permits issued has remained relatively steady since 1998 (figure 6.25). The area of habitat affected since 1996 has not been published. Similarly, while construction works in, on or above land under tidal water (such as the building of jetties, pontoons, boat ramps, decks, boardwalks, wharves, pipelines, mooring piles and similar works) are also regulated (table 6.21), the cumulative impact of these works on habitat has not been assessed.

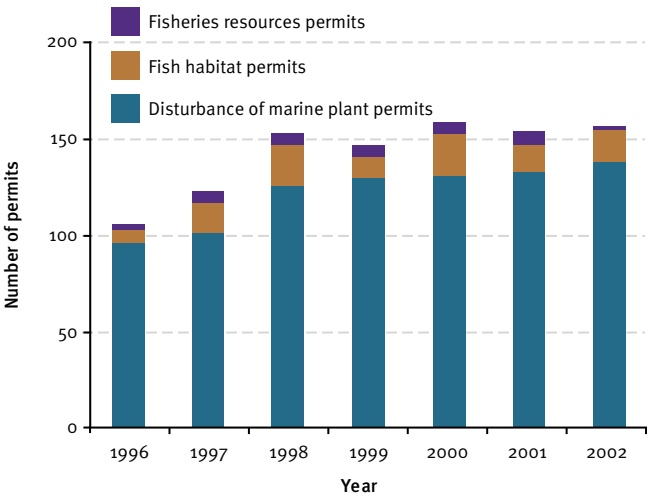


Figure 6.25 *Number of permits to disturb marine plants issued under provisions of the* Fisheries Act 1994, *1996–2002*
Source: DPI

Table 6.21 Construction work sanctions in Queensland's tidal waters, under the *Harbours Act 1955*

Fiscal year	Number of sanctions granted
1995–96	›459
1996–97	517
1997–98	563
1998–99	543
1999–2000	676
2000–01	480
2001–02	557

Source: EPA

Resource use

The coastal and marine environment holds resources that are significant to the human populations that reside in the coastal zone and beyond. Activities such as fishing, hunting, shipping and tourism place pressure on habitat and biodiversity. Pressures arising from the use of coastal and marine resources are discussed in 'Coastal resource use and development'.

Fishing

Fishing places pressure on biodiversity by removal of target and non-target species from the ecosystem, and disturbance of habitat through fishing practices. The impact of demersal (bottom or seabed) trawling in the Great Barrier Reef has been the subject of contention as agencies attempt to develop and implement management strategies for this practice (WWF 2002). Current estimates of trawl effort and bycatch are given in 'Coastal resource use and development'.

Exploitative and environmental pressures on Queensland's fisheries are increasing as a result of the growing demand for seafood products, especially in export markets. Recreational fishing pressure has the potential to increase due to population growth and coastal development. However, information suggests that increasing population is being offset by a declining participation rate in recreational fishing. Areas of the coast that were once considered remote and difficult to reach for recreational fishing, such as Cape York and the Gulf of Carpentaria, are experiencing increasing visitor pressure.

Introduced species and species outbreaks

Coastal and marine ecosystems are subject to the disruptive effects of outbreaks of species that have destructive impacts on the ecology of the areas they colonise. These species may be introduced, as in the case of lantana or black striped mussels (see 'Marine pests' below), but also may be naturally occurring species that periodically surge in numbers. In Queensland's coastal environment the crown-of-thorns starfish and the toxic cyanobacterium *Lyngbya majuscula* arouse concern because of both their environmental and their economic impacts. Another organism to receive some attention owing to its impact elsewhere is the toxic alga Pfiesteria, which has been found in a number of Queensland estuaries. While it has the potential to kill fish and also affect human health, no significant impact has been measured in Queensland.

Plants

The issue of introduced plants is dealt with more generally in Chapter 4, 'Land', and Chapter 7, 'Biodiversity'. However, a number of introduced plant species specifically threaten coastal vegetation communities. Of the 20 listed weeds of national significance (Thorp and Lynch 2000), 10 occur in coastal areas of Queensland (table 6.22). One of these, pond apple, is a weed of particular concern in the Wet Tropics bioregion, where it invades a wide range of habitats.

Table 6.22 Occurrence of weeds of national significance in coastal areas of Queensland

Common name	Scientific name	Rank
Blackberry	*Rubus fruticosus* agg.	3
Lantana	*Lantana camara*	4
Rubber vine	*Cryptostegia grandiflora*	5
Bitou bush/boneseed	*Chrysanthemoides monilifera*	6
Prickly acacia	*Acacia nilotica* ssp. *Indica*	7
Hymenachne	*Hymenachne amplexicaulis*	8
Salvinia	*Salvinia molesta*	9
Cabomba	*Cabomba caroliniana*	11
Parthenium weed	*Parthenium hysterophorus*	16
Pond apple	*Annona glabra*	17

Source: Thorp and Lynch 2000





Blackberry is a weed of national significance. (Photos: EPA)





Salvinia blanketing a waterway (Photos: EPA)

Lyngbya

Lyngbya majuscula (Lyngbya) is a cyanobacterium that has been recorded along the Queensland coast since 1911. Lyngbya blooms smother shoreline plants and overgrow seagrasses, with possible consequences for dugong that rely on seagrasses for food. Lyngbya also poses a risk to human health, having toxic effects on the skin, eyes and respiratory tract. Outbreaks of Lyngbya blooms are associated with dissolved iron and phosphorus, but the precise mechanism is yet to be determined. The cause is thought to be linked to transport of these materials, which result from human activity in nearby catchments, through surface water and groundwater to the bloom sites (MBWCP 2002).

Increasing Lyngbya outbreaks have been reported in Deception Bay since 1990 and in other parts of Moreton Bay since 1997. At the end of 2002, five areas along the Queensland coast had signs of Lyngbya blooms: Hinchinbrook Island, Hardy Reef, Shoalwater Bay, Great Keppel Island and Moreton Bay. Localised bloom areas in Moreton Bay include northern Deception Bay, the eastern banks and southern parts of Moreton Bay, and Redland Bay.

Crown-of-thorns starfish

Damage to Great Barrier Reef corals by the crown-of-thorns starfish (COTS) has been monitored at a broad scale by the Australian Institute of Marine Science since 1985. Results from these surveys show that in 2000, as in 1999, outbreaks of COTS were observed on 17% of reefs surveyed (Sweatman et al. 2001). This is equal to the highest levels recorded since surveys began, also being measured in 1987. The mean density in 2000 was recorded at 0.96 COTS per tow, due to high densities reported for the Innisfail area. This compares with a figure of 1.18 measured during the last major outbreak in 1988.

The distribution pattern of the outbreak, with declining numbers in the Cooktown–Lizard Island area and large numbers in the Cairns, Innisfail and Townsville sectors (figure 6.26), is consistent with the hypothesis that larvae are transported southward by the East Australian Current, but the exact mechanism of the COTS outbreaks is yet to be determined (Engelhardt and Lassig 1997). Changes to the reef ecosystem caused by increased anthropogenic activity are suspected of contributing to COTS outbreaks.

Marine pests

Since the outbreak of an infestation of black striped mussels in Darwin harbour in 1999, the possible introduction of marine pests by visiting ships has been increasingly recognised as a serious threat to marine biodiversity. Pests may be introduced either through attachment to the hull of a ship or through the discharge of ballast waters around ports. Queensland has 15 ports designated to receive international ships, which can discharge up to 60 000 tonnes of ballast water on a visit (PCQ 2003). It is estimated that 2.5 million tonnes of ballast water is discharged annually to the Port of Brisbane (CRC Coasts 2002a). The likelihood of introduction of pests is dependent on the number of ships' visits (table 6.23), the volume of ballast discharged, the source of ballast water and the effectiveness of management controls, which are being developed for the shipping industry and port authorities at international, national and state levels.

In March 2003 the National Introduced Marine Pest Information System (NIMPIS) listed 24 pest species (15 known introductions and 9 possible introductions) either recorded or posing a threat in Queensland (table 6.24), updating information contained in 1999 (EPA 1999a).

Table 6.23 Number of ships' visits to Queensland ports

Port	Number of visits[1]			
	1991–92	1999–2000	2000–01	2001–02
Brisbane	1 580	2 356	2 211	2 208
Gladstone	676	933	969	969
Hay Point	516	731	764	759
Cairns	463	516	571	463
Townsville	376	651	718	376
Weipa	295	302	291	328
Karumba	21	157	49	134
Abbot Point	81	93	106	119
Rockhampton	68	80	70	61
Cape Flattery	40	36	38	35
Mourilyan	25	36	26	31
Lucinda	16	19	11	18
Quintell Beach[2]	NA	57	0	0
Skardon River[3]	0	0	0	0
Thursday Island[2]	193	282	705	NA
Bundaberg	163	44	33	NA
Mackay	121	150	140	NA
Total	**>8 617**	**10 442**	**10 703**	**>9 504**

[1]Figures taken from annual reports of relevant port authorities, AAPMA 2003 and Tarte et al. 1993. Where discrepancies occur, the port authority figure is given precedence. NA = not available
[2]Community port
[3]New port declared in 2002

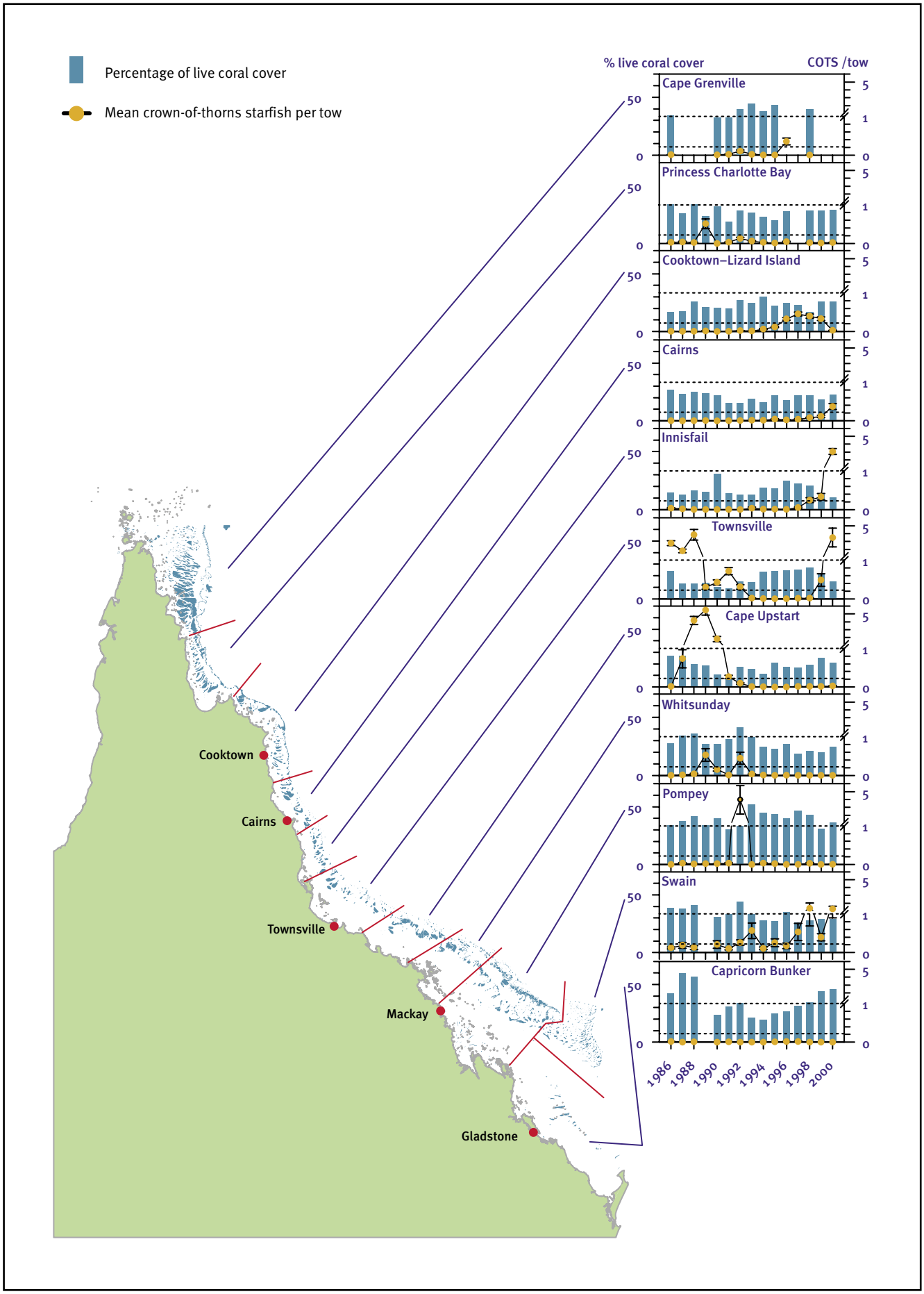


Figure 6.26 *Crown-of-thorns starfish activity on the Great Barrier Reef, 1986–2000*
Source: Sweatman et al. 2001

Table 6.24 Marine pests listed for Queensland in the National Introduced Marine Pest Information System (NIMPIS)

Species name	Common name	Status of introduction	Mode of introduction
Amathia distans	Bryozoan	Known	Fouling
Anteaeolidiella indica	Japanese aeolid	Possible	Fouling, dry ballast
Botrylloides leachi	Colonial ascidian	Possible	Fouling
Botryllus schlosseri	Star ascidian	Known	Fouling
Bugula flabellata	Bryozoan	Known	Fouling
Bugula neritina	Bryozoan	Known	Fouling
Caulerpa taxifolia	Aquarium caulerpa	Possible	Natural dispersal, aquatic
Ciona intestinalis	Solitary ascidian	Known	Fouling
Cordylophora caspia	Hydroid	Known	Ballast water
Cryptosula pallasiana	Bryozoan	Known	Fouling
Halecium delicatulum	Hydroid	Possible	Fouling
Hopkinsia plana	Sea slug	Known	Fouling
Hydroides elegans	Fouling serpulid	Possible	Fouling, natural dispersal
Megabalanus tintinnabulum	Acorn barnacle	Possible	Fouling
Obelia dichotoma	Hydroid	Possible	Fouling, natural dispersal
Paracerceis sculpta	Sponge isopod	Known	Ballast water, fouling
Paradella dianae	Sphaeromatid isopod	Known	Fouling
Plumularia setacea	Hydroid	Possible	Fouling, natural dispersal
Schizoporella unicornis	Lace coral	Known	Fouling, oysters accidental
Sphaeroma walkeri	Marine pill bug	Known	Fouling
Styela plicata	Solitary ascidian	Known	Fouling
Teredo navalis	Naval shipworm	Known	Fouling
Ulva fasciata	Sea lettuce	Possible	Fouling
Watersipora arcuata	Lace coral	Known	Fouling

Source: Hewitt et al. 2002

Coral bleaching and climate change

Climate change caused through the greenhouse effect (see 'Coastal variability–physical processes' and Chapter 3, 'Atmosphere') represents a threat to ecological processes along the Queensland coast through increased storm activity and higher ocean temperatures. There is particular concern about the increasing likelihood of coral bleaching episodes, which are associated with elevated sea temperatures. In 2002 the worst recorded coral bleaching episode was experienced in the Great Barrier Reef. Almost 60% of 641 reefs surveyed showed evidence of bleaching, although the effect ranged from negligible to severe. The most severe bleaching occurred on inshore reefs, where approximately 50% of reefs were bleached to high or very high levels (GBRMPA 2003a).

Condition and trends

Regional biological diversity of marine and coastal areas

Biological diversity (biodiversity) can be measured at a number of levels. The *Nature Conservation Act 1992* recognises four levels of biodiversity, from a landscape or regional level, to ecosystem level, through to species and finally genetic diversity levels. Similarly, a hierarchy of classification has also been recognised by the Commonwealth, which developed a bioregional classification of Queensland's marine waters, grouping them into 14 bioregions under the Interim Marine and Coastal Regionalisation for Australia (IMCRA Technical Group 1998).

The Great Barrier Reef Marine Park Authority has used multiple criteria to reclassify the marine environment within the Great Barrier Reef World Heritage Area into more than 70 sub-IMCRA bioregions (GBRMPA 2001; EA 2002a). While it is difficult to delineate functional ecosystems in the marine environment, these sub-bioregional areas were defined through aggregation of component habitats and communities, mapped at a finer scale, or through expert consensus (EA 2002a).

Sub-bioregional boundaries for the marine environment outside the Great Barrier Reef have not been established. However, knowledge of Queensland's coastal and marine habitats has been gradually advancing since 1999, with better mapping, in both extent and scale, for some coastal habitat types. Yet for other habitat types, little or no new information is available as a result of changing research priorities or reduction in available resources.

Coastal and marine habitat

Riparian vegetation

Analysis of mapped riparian vegetation data shows variation between the coastal areas of Queensland's bioregions (table 6.25). High levels of wetland vegetation, particularly in Broadsound, near St Lawrence, account for the high proportion occurring in the coastal zone of the Brigalow Belt.

Table 6.25 Area and percentage of riparian vegetation* within the coastal zone of Queensland's bioregions

Bioregion	Riparian area in coastal zone (ha)	Percentage
Brigalow Belt (North and South combined)	231 754	55
Central Queensland Coast	69 139	27
Southeast Queensland	129 399	20
Wet Tropics	47 549	18
Cape York Peninsula	NA	NA
Gulf Plains	NA	NA
Total	**477 841**	**10**

*Riparian vegetation includes riparian/floodplain eucalypt open forests and woodlands, and wetlands (sedgelands, melaleucas, lakes).
NA = not available

Source: EPA

Shoreline

Queensland's shoreline has been classified into 40 shoreline habitat types through analysis of aerial photography and low-altitude digital videos (Banks and Skilleter 2001). The marine shoreline of the mainland is dominated by sandy substrates, while islands have a more even mix of sand, boulders, rock and fringing reefs (table 6.26). Mixed fines substrate accounts for approximately 90% of estuarine shoreline habitats on both mainland and islands. The greatest diversity of habitat types is in the Lucinda–Mackay IMCRA bioregion, associated with the combination of the range of habitats on the Whitsunday Group with the mainland, while the Karumba–Nassau bioregion has the lowest diversity.



Queensland's mainland shoreline is mainly sand, while its islands have a mix of sand, rock and fringing reefs. (Photo: EPA)

Table 6.26 The lineal extent of shoreline habitat types as mapped for each marine and estuarine subsystem as a percentage of the length of Queensland's coastline

Shoreline habitat group	Number of habitat types	Marine		Estuarine	
		Mainland	Island	Mainland	Island
		%	%	%	%
Mixed fines	5	30.5	12.7	90.2	90.5
Sand	4	51.9	30.4	8.3	6.5
Rock, ramp, platform, cliff	5	6.7	24.5	0.2	1.0
Fringing coral	2	1.0	14.4	0.0	0.0
Boulder	5	5.6	9.1	0.0	0.1
Cobble	5	1.9	5.5	0.1	0.0
Gravel	4	1.0	3.2	0.0	0.2
Human-made	3	0.8	0.2	1.1	1.6
Beach rock	4	0.5	0.1	0.0	0.0

Source: Banks and Skilleter 2001

Endangered ecosystems in the coastal zone

Within the coastal zone, there are 83 endangered regional ecosystems with an area of 61 670 ha (table 6.27). The area that appears to be under the greatest threat is the Central Queensland Coast, which has 45% of the area (and 30% of the number) of Queensland's endangered coastal ecosystems.

Table 6.27 Number and area of endangered ecosystems in the coastal zone (islands and areas below 10 m contour) of Queensland's bioregion

Bioregion	Number	Area (ha)
Central Queensland Coast	25	27 600
Wet Tropics	22	15 240
Southeast Queensland	12	15 030
Brigalow Belt North	22	3 750
Brigalow Belt South	1	50
Cape York Peninsula	1	0
Total	**83**	**61 670**

Note: Areas are rounded to the nearest 10 ha.

Source: EPA

Estuarine and marine wetlands

Two additional coastal wetlands for Queensland have been included in the third edition of *A Directory of Important Wetlands in Australia* (EA 2001a); they are the Shoalwater Bay Training Area Overview (454 000 ha) and the Wide Bay Military Training Area (19 990 ha). This brings the total number of wetlands in Queensland classified wholly or partially as coastal (Category A) to 69 (table 6.28). Of these, three are marine, associated with the Great Barrier Reef area, while the remaining 66 are terrestrial, with a total area of 3 786 555 ha. Differences between these figures and those in 1999 (EPA 1999a) result from an analysis based on the classification system of wetlands, rather than proximity to the coastline.

Table 6.28 Area and number of important wetlands wholly or partially classified as coastal

Area/bioregion	Coastal wetlands	
	Number	Area (ha)
Great Barrier Reef	3	34 251 469
Gulf Plains	6	1 034 114
Central Mackay Coast	13	713 129
Cape York Peninsula	14	667 181
Southeast Queensland	10	660 158
Brigalow Belt North	6	441 749
Brigalow Belt South	5	142 072
Wet Tropics	12	128 153
Total	**69**	**38 038 024**

Sources: EA 2001a; EPA

Mangroves

In 2000 DPI released new spatial data for coastal wetland vegetation, which give a more detailed indication of the extent of mangroves, saltmarsh and seagrasses than previously available (de Vries et al. 2002). Table 6.29 gives the area of mangrove forests and saltmarsh for seven marine bioregions of Queensland. The greatest area of mangroves occurs in Cape York Peninsula. Differing methods and reporting areas make comparison with previous data difficult. Two estimates of the total area of mangrove forests in Queensland in 1982 were given in 1999: 4603 km² and 3135 km² (EPA 1999a). The overall figure in the latest mapping, 3494 km², calculated from de Vries et al (2002), does not show any sharp difference from the previous figures.



Mangroves line a waterway on South Stradbroke Island. (Photo: D. Jew, EPA)

Over a long period, particular mangrove forests in Queensland have undergone marked changes. Some of the changes have been due to direct clearing. However, with increasing intrusion of saline water into rivers resulting from dam construction and channel dredging, mangroves have also extended further upstream in a number of rivers, replacing saltmarsh in some areas. Regional studies provide details of changes to mangroves in particular areas of Queensland's coast which may have local significance. For instance, a study of the changes in mangrove forests of Moreton Bay between 1974 and 1997 reported a net loss of 200 ha (1%) of mangrove forest (CRC Coasts 2001), the reported area of mangroves in Moreton Bay in 2002 being 15 300 ha (CRC Coasts 2002b).



The condition of mangroves may be affected by the build-up of pollutants in the sediment and influences upstream. (Photo: EPA)

Table 6.29 Areas of mangroves and saltmarsh in Queensland's bioregions

Bioregion	Mangroves (km²)	Saltmarsh (km²)
Cape York Peninsula	978	664
Brigalow Belt North	805	994
Gulf Plains	499	4874
Southeast Queensland	440	172
Wet Tropics	409	31
Central Queensland Coast	362	121
Brigalow Belt South	1	0
Total	**3494**	**6856**

Source: DPI

Other pressures affect not just the extent of mangrove forests but also the condition. A study in the Mackay area revealed a possible link between a large dieback occurrence in 2001 that affected approximately 50 km² of mangroves and the presence of herbicide in sediment (Duke et al. 2001). Another study of the occurrence of mutant propagules of the common mangrove genus *Avicennia* in south-east Queensland showed that the health of mangrove forests may be affected by oil in sediments (Duke and Watkinson 2002)

Saltmarsh

Mapping by DPI has also increased the known extent of saltmarsh in Queensland reported in 1999 to 6900 km², an increase of almost 50%. The increase is due mainly to better resolution in spatial measurements using satellite technology, and incorporation of the area of saltpan habitats into the saltmarsh mapping classification. This would account for a significant increase in estimates for the Gulf of Carpentaria to almost 5000 km² of saltmarsh, which remains a significant habitat for migratory waders (see 'Birds', page 6.61).

Studies in particular areas of Queensland have revealed changes at a local or regional level that affect ecosystems. For example, in the area from Raby Bay to the Nerang River, an area of increasing population density (see 'Coastal resource use and development'), net loss of saltmarsh is estimated to have been 3430 ha between 1955 and 1998. Of this, 1442 ha had been colonised by mangroves (SEQRWQMS 2002).

Melaleuca wetlands

There are no additional data on the extent of melaleuca wetlands in Queensland since 1999, the total amount being unknown. Similarly, there is no new information on the loss of melaleuca wetlands for the Moreton Bay area, which were reported to comprise less than 390 ha in 1982 (Catterall and Kingston 1993).



The extent of melaleuca wetlands in Queensland is unknown. (Photo: EPA)

Seagrass

Contributed by Stuart Campbell, Len McKenzie and Rob Coles

Considerable progress has been made in increasing knowledge of seagrasses in Queensland. Numerous studies, including community-based monitoring and studies commissioned by various port authorities have augmented broadscale studies by DPI.

Queensland has 15 species of seagrass, representing 25% of the world's seagrasses. Seagrass meadows are important for stabilising coastal sediments and providing food and shelter for diverse organisms, as a nursery ground for shrimp and fish of commercial importance, and for nutrient trapping and recycling. The marine mammal *Dugong dugong* and the green sea turtle (*Chelonia mydas*) feed directly on seagrasses.

Seagrass communities in Queensland have remained relatively stable over the past three years. Low rainfall associated with the recent El Niño climatic pattern (2001–02) has resulted in a relatively low discharge of sediment-laden fresh water from river systems. Seagrass meadows that were damaged by floodwaters in some areas of northern and southern Queensland in 1999–2000 have recovered.

Queensland's seagrasses are mostly found growing in waters less than ten metres below mean sea level, although some species of *Halophila* can be found to depths of 60 m. Species diversity of seagrass meadows tends to decline from north to south. While knowledge of intertidal and shallow subtidal (down to 10 m) distributions is good, there is only a basic understanding of deepwater (›10 m) seagrasses.

The Gulf of Carpentaria

Twelve species of seagrass are found in the Gulf of Carpentaria, mostly in inlets and bays. Their distribution was last mapped extensively in 1986, showing 4.1 km² of seagrass present. Recent repetitive mapping associated with port activities in Weipa, Karumba, Skardon River and Kirke River suggests that the existing distribution of seagrass is similar to that in 1986, but it is highly seasonal, temporary declines being associated with flooding during the wet season (Sheppard et al. 2000; Roelofs et al. 2001, 2002a, 2002b; Rasheed and Thomas 2002).

Torres Strait

Surveys of the open waters of Torres Strait have led to estimates of 13 425 km² of seagrass habitat (Long and Poiner 1997), much of which is valuable habitat for juvenile commercial shrimp. It is likely that thousands of hectares have been lost in north-west Torres Strait, but these are remote locations and difficult to monitor effectively.

The Great Barrier Reef

The best estimates of the area of seagrass meadows along the east coast are 5668 km² of intertidal and shallow subtidal habitat (down to 15 m water depth) (Coles et al. 2001 a–e; DPI unpublished data). The area of seagrass meadows in reef lagoon waters of the Great Barrier Reef World Heritage Area deeper than 15 m (figure 6.27) is likely to be as high as 40 000 km² (Coles et al. 2000).

Detailed regional assessments of seagrasses in the Great Barrier Reef region have been made at Lizard Island, Low Isles, Cairns Harbour, Green Island, Mourilyan Harbour, Hinchinbrook Channel and Mackay (Campbell et al. 2002a, 2002b; Thomas and Rasheed 2001; Rasheed et al. 2001). The Mackay (Coles et al. 2002) and Shoalwater Bay areas (Lee Long et al. 1997) were included for dugong management. These studies show that meadows have remained relatively stable over the past eight years, some declines in seagrass area in late 2001 being linked to high rainfall and catchment inputs.

On the central Queensland coast surveys of the islands and bays of the Whitsundays in 1999–2000 showed that in most areas seagrass distribution had remained stable between 1987 and 2000, although losses of about 300 ha of seagrass in Pioneer Bay have been linked to nutrient inputs and algal blooms (Campbell et al. 2002a). In southern Queensland estuaries and bays, declines of seagrasses resulting from coastal development, flooding and cyclones have been followed by partial recovery in a number of regions including Hervey Bay (Preen et al. 1995; McKenzie and Campbell 2003) and Townsville.

In waters deeper than 15 m there is a noticeable change in seagrass distribution and abundance from north to south. Seagrass meadows are sparse north of Princess Charlotte Bay and south of Mackay in the area where tidal velocities are high. The highest seagrass densities occur between Princess Charlotte Bay and Cairns and south of 23°S.

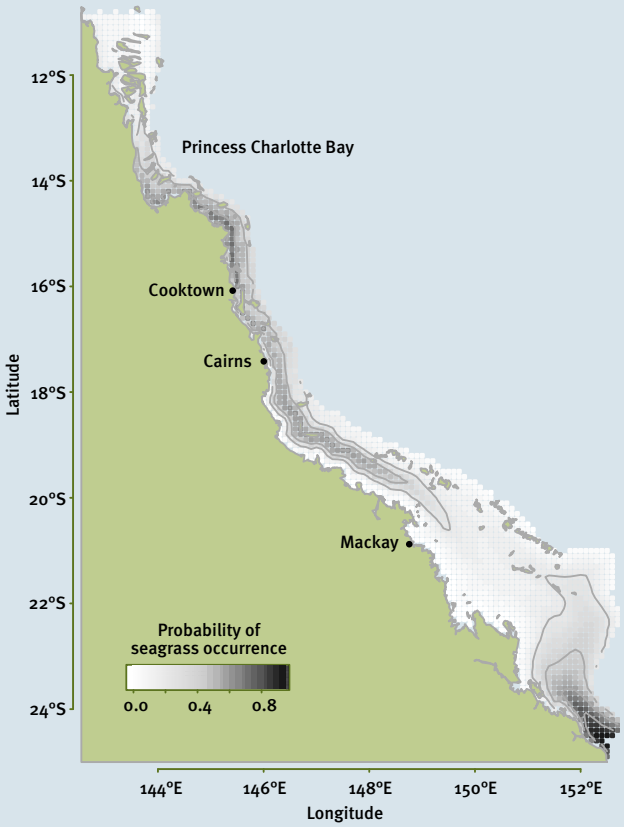


Figure 6.27 *Occurrence of deepwater seagrass in the Great Barrier Reef lagoon (contours obtained from spatial smoothing)*
Source: DPI

Coral reef systems

Coral reef systems occur throughout Queensland's coastal areas, including the Gulf of Carpentaria and along the east coast, the vast majority being located in the Great Barrier Reef. There the Australian Institute of Marine Science conducts a long-term monitoring program (Sweatman et al. 2001) designed to examine population trends in a number of key organisms, including corals, and to estimate population changes in the threatening crown-of-thorns starfish (COTS). Results show that the major changes in the six years up to 2000 were due to damage by cyclones and COTS (see 'Introduced species and species outbreaks', page 6.46), and subsequent recovery. There was also a major bleaching episode in 1998–99. Coral cover over this six-year period was decreasing in the inshore and mid-shelf regions of the Cairns, Innisfail and Townsville sectors (table 6.30). Figure 6.28 shows trends for the past six years.

There is growing debate about the impacts of declining water quality on the capacity of the reef to regenerate after cyclone and storm damage, with evidence emerging that increasing nutrients and sediments resulting from human activity diminish reef recovery in an incremental fashion (PC 2003). Coral coverage is declining in nearshore fringing reefs in the central section of the Great Barrier Reef, while sediment and algal coverage is increasing (WWF 2001).

In 1997, there were 359 species of hard coral species recorded and 80 genera of octocorals (soft corals) reported as probably occurring in the Great Barrier Reef region (Stokes and Dobbs 2001). Species composition is shown to vary from inner shore to outer reefs. A survey of soft corals on the Great Barrier Reef between 1996 and 1999 published in the *Soft Coral Atlas* (Fabricius and De'ath 2002) provides details of the geographic distribution and abundance of the 36 most common genera. Average coverage of the sites surveyed was 12.5%, with coverage ranging from 0% to 90%.

Soft-bottomed systems

The vast majority of the sea floor is soft-bottomed habitat. For instance, 95% of the Great Barrier Reef Marine Park is comprised of this type of habitat (Wachenfeld et al. 1998). Species that are commonly found in epibenthic communities on the soft sea floor of the Great Barrier Reef include:

- echinoderms (feather stars, sea stars, pincushion stars, brittle stars, basketstars, urchins and sea cucumbers);
- molluscs (sea snails, slugs, limpets, scallops, oysters, clams, cuttlefish, nautilus, squid, octopuses);
- crustaceans (prawns, crabs, lobsters, barnacles);
- demersal (associated with the sea floor) fishes;
- bryozoans (lace corals and other moss animals);
- ascidians (sea squirts);
- sponges;
- cnidarians (anemones, jellyfish, hard and soft corals, gorgonians, sea fans, sea whips and other horny corals);
- seagrasses (shallow water and deep water); and
- algae (*Halimeda* mounds).

New knowledge of the range of species and the extent of seagrasses growing in deeper waters has been acquired by surveys involving towing video cameras. Similarly, surveys have extended knowledge of sponges (see 'Invertebrates' below). There is concern about the impact of trawling on benthic communities in soft-bottomed systems (WWF 2002). Preliminary results from a joint CSIRO-DPI study were reported in 1999 (EPA 1999a). Since then the results have been extrapolated to roughly estimate that the average total annual removal of fauna from all trawled grids in the marine park may have been about 10% a year, depending on the resilience of the fauna, but there is a need to examine the recovery rates, for which little information is available (Poiner et al. 1998a, 1998b).



Crustaceans, including prawns, are commonly found on the soft sea floor of the Great Barrier Reef. (Photo: EPA)

Table 6.30 Coral coverage of reefs surveyed in sections of the Great Barrier Reef

Section	Year of survey	Number of reefs surveyed	Average reefwide coral cover (%)	Range (%)	Bleaching evidence	COTS	Disease presence	Notes
Far Northern	2001	10	27	10–43	Not reported	Low numbers		Survey of 18 reefs showed decrease from 31% in 1999 to 27% in 2001
Cairns	2001 and 2002	32	21	3–43	Inner shelf reefs also in 1997–99		White syndrome on outer shelf reefs	
Central	2001	28	20	5–43	Inshore reefs	Outbreak in north moving south		Same cover as in 2000
Mackay–Capricorn	2001	15	36	17–61	Inshore fringing reefs	Not episodically following northern outbreak; 4 of 7 reefs had outbreaks		Survey of NE-facing sites on 11 reefs put hard coral estimates at 41%

Source: Sweatman et al. 2002

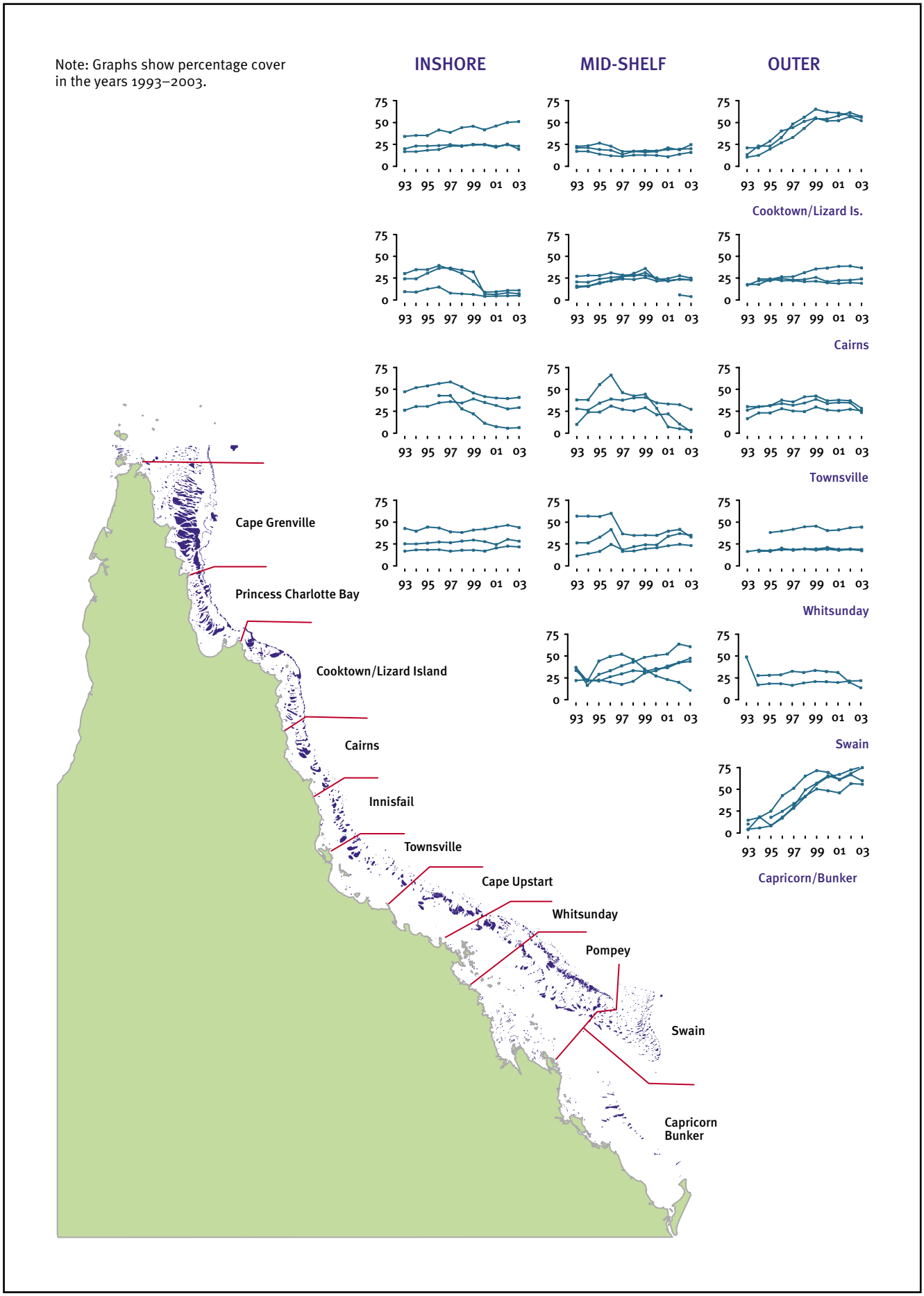


Figure 6.28 *Trends in hard coral coverage at 48 sites in selected sectors of the Great Barrier Reef, 1993–2003*
Source: Sweatman et al. 2001, AIMS

Mid-water column

The mid-water column system in Queensland's marine environment supports an enormous array of plant, animal and microbial life. It provides the physical support for life forms and the medium through which nutrients are transported, linking other habitat types from which it cannot be separated. The character of the mid-water column is determined by ocean currents, climate, catchment runoff and nearby human activities, as well as the biological processes that take place within the column itself. These issues are dealt with in 'Coastal resource use and development', Coastal water quality' and 'Coastal variability—physical processes'.

Species diversity, distribution and population trends

Queensland's coastal habitats support a very large number of plants, animals and microbial species. There have been steady advances in the knowledge of the diversity of Queensland's marine and coastal plants, animals and microbes since 1999, but significant gaps remain. The assessment of population trends continues for some threatened species, particularly turtles, whales and dugong. For endangered terrestrial species, however, population trends have been difficult to measure in cases where numbers of the species in question are at very low levels and monitoring programs have not been designed to detect change at these levels (Latch, P., pers. comm.).

Microbial life

The importance of microbes in the marine environment is the subject of wide-ranging research with ecological, health, agricultural and industrial significance. Microbial life forms include bacteria, fungi and unicellular plants and animals, including the organisms that produce coral. Some are free living; others live in close association with marine flora and fauna, some as pathogens; and others live in mutually advantageous, or symbiotic, relationships. One example of a symbiotic relationship is a cyanobacterium that lives within some coral reef-dwelling species of sponge, providing them with energy sources in return for a protective environment. On the other hand, pathogenic microbes are associated with diseases in coral, particularly under stressed conditions (CRC Reef 1999).

Other micro-organisms play an important role in the nutrient status of marine ecosystems. Photosynthetic microalgae live in the sediment (benthos) or are free living in the water column. Their photosynthetic activity plays a critical role in oxygenating water, and in carbon cycles. Their growth is often limited by lack of other nutrients, or adverse environmental conditions, but under favourable conditions these micro-organisms bloom, turning water brown or green, and can disturb ecological processes. One group of phytoplankton, the dinoflagellates, is also of interest because particular species cause shellfish poisoning. Their presence has been detected in Moreton Bay, and blooms have been associated with sewage-derived nutrients. More generally, in Moreton Bay the diversity of phytoplankton has been shown to be largely related to water quality, with lower diversity found in turbid and nutrient-enriched waters (UQ 2003).

It is very difficult to adequately describe the diversity of bacterial life in marine environments. Bacteria evolved well before other organisms (over 3.8 billion years ago) and display greater genetic and metabolic diversity than plants and animals put together (Sly 1998). They may live in extreme environments and often have unique functions in nutrient cycling. In the marine environment they play an important part in carbon cycling, and some have ecological significance: for example, the photosynthetic cyanobacteria which, in the presence of favourable nutrient and climatic conditions, form algal blooms. Other bacteria cause diseases of plants and animals (having been implicated in the death of turtle eggs).

Macroalgae

A database of macroalgae has been established within the Australian Biological Resources Study, which extends the numbers of species known to occur within Queensland's coastal zone (table 6.31).

Table 6.31 Number of marine macroalgae species identified in Queensland waters

Family	Gulf of Carpentaria	Great Barrier Reef	Southern
Chlorophyta	67	195	75
Cyanophyta	1	0	0
Heterokontophyta, Class Phaeophyceae	46	111	59
Rhodophyta	96	323	148
Total	**210**	**629**	**282**

Source: Cowan et al. 2000

Invertebrates

While the overall status of knowledge of marine invertebrates remains poor (Ponder et al. 2002), there has been some growth in understanding of the rich species diversity of marine invertebrates in Queensland waters since 1999, resulting from surveys and supporting research, with the identification of new species and development of taxonomy (QM 2001, 2002), the development of the Marine Representative Areas Program in the Great Barrier Reef, and through surveys conducted in various Queensland ports. More is known about the invertebrates of the intertidal and shallow waters of the Great Barrier Reef and southern Queensland than those in the rest of the state's coastal areas (Ponder et al. 2002).

As part of the Introduced Marine Pests Program, Queensland ports have conducted biological surveys within port limits, during which new species have been identified. For example, in the Port of Townsville several crustaceans new to science were collected during a survey in 2000; they included a pycnogonid from the Family Austrodecidae and three new species of isopods from the Families Paranthuridae and Anthuridae (PoT 2002). New species from other phyla, such as Platyhelminthes (stylochid flatworms), have also been described (Beveridge 2000).

Another reason for increasing our knowledge of invertebrates, particularly sponges, is the potential of compounds from marine organisms to be used in medicine or other biotechnological applications. In 2002 the Queensland Museum conducted biological expeditions at 650 locations in the Great Barrier Reef and Coral Sea, and has developed a database of sponge species distribution (QM 2002), along with a guide to sponge classification (Hooper 2000).

One group of invertebrates of particular interest because of their effect on people swimming in north Queensland has been the jellyfish that cause 'Irukandji syndrome'. While only one species, *Carukia barnesi*, has been proven to cause 'Irukandji syndrome' it is believed that at least six species cause symptoms (CRC Reef 2002).

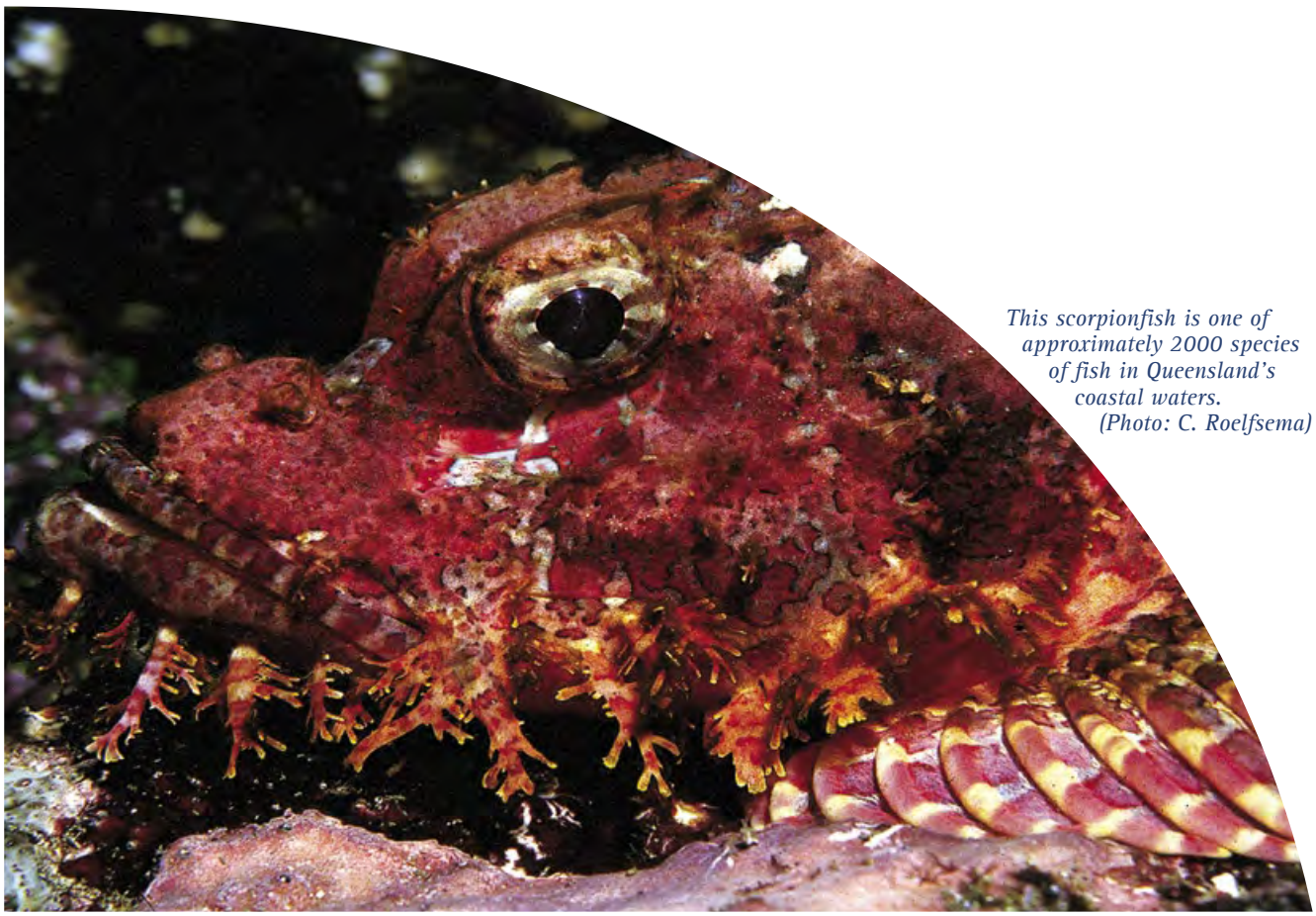
Fish

The estimate of the number of species of fish in Queensland's coastal waters remains at approximately 2000, with 1500 the most common estimate for fish from the Great Barrier Reef (Stokes and Dobbs 2001). A checklist of 750 fish species for Moreton Bay was published in 1999, extending the known range of many species (Johnson 1999). Of these, 355 are considered relatively rare within the Bay environment.

In a survey conducted by the Queensland Museum of bycatch from prawn and scallop trawlers, up to 16 new species have been detected, from depths of between 30 and 150 metres. Analysis of bycatch offers the possibility of increasing knowledge of fish from these depths (QM 2002).

Population studies and broad surveys are contributing to knowledge of wild fish stocks and understanding of the population dynamics of fish. DPI started a long-term monitoring program for nine fisheries in 1999 (DPI 1999). Preliminary results for barramundi and reef fish show season-to-season variation, but insufficient data exist to establish trends (DPI 2003a, 2003b). Figure 6.29 shows the relative abundance of reef fish estimated from monitoring results in 2001.

The long-term monitoring program on the Great Barrier Reef (Sweatman et al. 2001) also reports on large fish and damselfish. Results show that populations of both have increased over the past six years in the Capricorn/Bunker sector, associated with an increase in coral cover. Other trends observed include a decrease in the number of families of larger fish in the Townsville sector, and increases in damselfishes in both the Cairns and Lizard Island sectors.



This scorpionfish is one of approximately 2000 species of fish in Queensland's coastal waters. (Photo: C. Roelfsema)

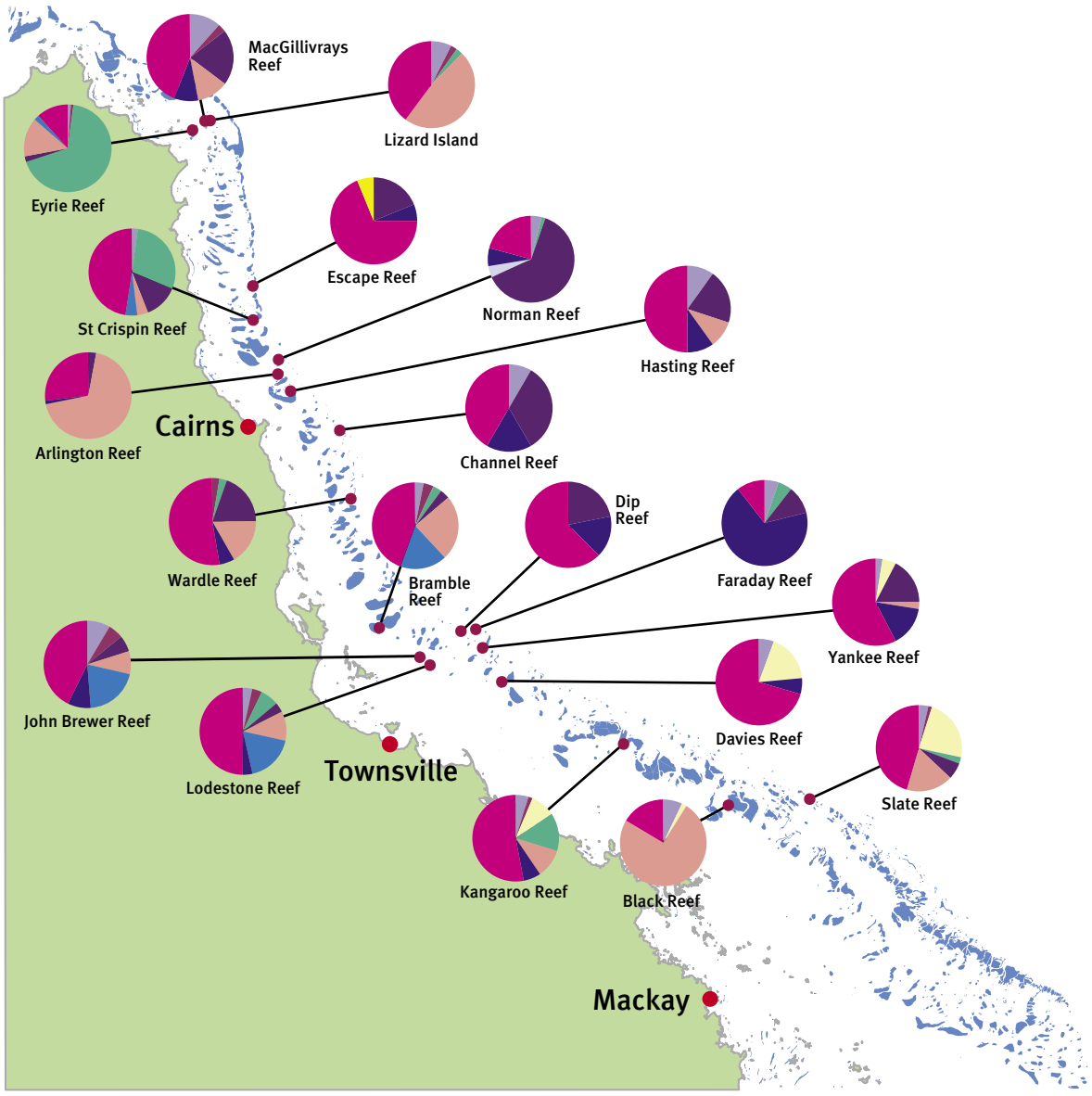


Figure 6.29 *Relative abundance of reef fish species*
Source: DPI

Reptiles

Turtles

Since 1999, there has been growth in knowledge of the six (of the world's seven) species of marine turtles found in Queensland waters, as a result of continuing research into nesting and breeding, population dynamics, feeding and migratory characteristics. This has been occurring within the international context, where data point to a continuing decline in populations of marine turtles in the Indian and Pacific Oceans (Abas 2000).

Hawksbill turtle

Approximately 4000 female hawksbill turtles (*Eretmochelys imbricata*) are estimated to nest in Queensland; these, together with an estimated 2500 females in eastern Arnhem Land, constitute one of the most significant nesting populations of this turtle in the world. Queensland has major nesting sites in central and eastern Torres Strait and the northern Great Barrier Reef (figure 6.30). A ten-year study on Milman Island showed an annual rate of decline of 3–4% in the nesting population (Limpus and Miller 2000), likely to be due to unsustainable harvesting of eggs and turtles. The hawksbill population that feeds and breeds in northern Queensland migrates to and from Indonesia, Papua New Guinea, the Solomon Islands and Vanuatu.



Hawksbill turtle (Photo: D. Jew, EPA)

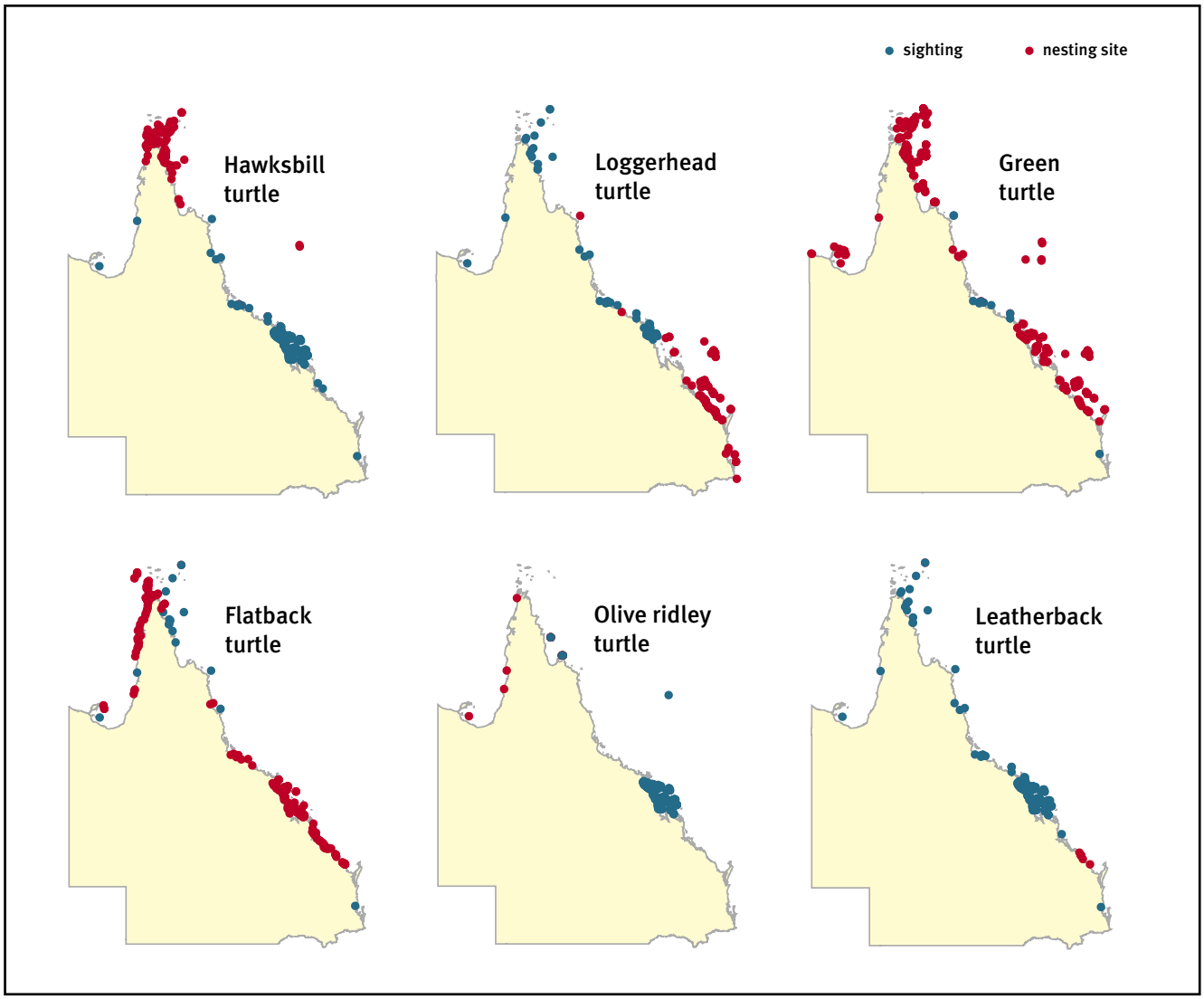


Figure 6.30 *Sea turtle nesting sites and other sightings in Queensland*
Source: EPA



Loggerhead turtle (Photo: EPA)

Loggerhead turtle

Fewer than 300 loggerhead turtles (*Caretta caretta*) nest annually in Queensland, a decline of 70–90% from the estimated population of 3500 in 1976–77. The breeding sites in the southern Barrier Reef and the Bundaberg coast (figure 6.30) support the only significant stock of loggerhead turtles in the South Pacific Ocean (Slater et al. 1998; Stokes and Dobbs 2001; Dobbs 2002). Data from Wreck Island in the Mackay–Capricorn marine bioregion collected in 2002 (figure 6.31) show that the rate of decline may have eased since the use of turtle exclusion devices (TEDs) on trawlers became mandatory in 2000, but this will be confirmed only by continued monitoring through the breeding cycle (Limpus, C.J., pers. comm.).

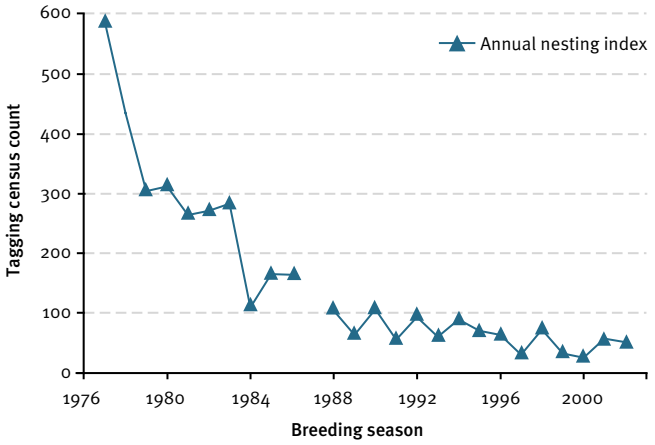


Figure 6.31 *Population trend of loggerhead turtles on Wreck Island*
Source: EPA



A green turtle at Raine Island (Photo: D. Jew, EPA)

Green turtle

There are four main breeding populations of green turtles (*Chelonia mydas*) in Queensland: the northern Great Barrier Reef, the southern Great Barrier Reef, the Coral Sea Islands Territory and the Gulf of Carpentaria (figure 6.30). Population trends are difficult to assess, as nesting turtle numbers fluctuate from year to year, mainly due to variable climatic conditions. Both the northern Great Barrier Reef population of about 30 000 nesting turtles and the southern Great Barrier Reef population of approximately 8000 are showing signs of being in the early stage of decline (Limpus 2000; Limpus et al. 2000a; Stokes and Dobbs 2001).

Flatback turtle

The flatback turtle (*Natator depressus*) is the only marine turtle that is endemic to Australian waters. Long-term monitoring of the eastern Australian population at rookeries in the central Great Barrier Reef region (figure 6.30) suggests that levels are stable (Limpus et al. 2000b). The northern population has not been extensively monitored, but it is thought that excessive predation of turtle eggs by pigs in west Cape York will put the population under some pressure.

Olive ridley turtle

There are two main breeding areas for olive ridley turtles (*Lepidochelys olivacea*) in Australia, one in the Northern Territory with about 1000 nesting females a year, and the other in the Gulf of Carpentaria with estimates of 100 nesting females a year. No nesting by the species has been recorded in the Great Barrier Reef area (GBRMPA 2003b). Recent information suggests that there may be an autumn nesting population in western Cape York Peninsula (Limpus, C.J., pers. comm.).

Leatherback turtle

No large rookeries for the leatherback turtle (*Dermochelys coriacea*) occur in Australia. While some Australian nesting occurs on the mainland coast near Bundaberg (figure 6.30) and along the coast of Arnhem Land, it is estimated that fewer than 10 animals nest annually in Australia (GBRMPA 2003c).

Sea snakes

Twenty-four species of sea snakes have been reported in Queensland waters. Of these, 17 species occur in the Great Barrier Reef (Hollister and Fowler 2001; Wachenfeld et al. 1998), while 11 have been found in Moreton Bay (QM 2003). Little information is available on their population dynamics.

A study of sea snakes caught as bycatch in the northern prawn fishery in 1989–90 shows the relative abundance of 14 species of sea snakes located in areas of the Gulf of Carpentaria targeted by prawn trawlers (Ward 2000). The two most common species found within Queensland waters were *Hydrophis elegans* and *Disteira major*, while the rarest were *Hydrophis pacificus* and *Enhydrina schistosa*. While there was no evidence for a collapse of the sea snake population in the Gulf, the study gave some signs that sea snakes are under threat. Fishermen anecdotally report that sea snakes are in decline, and the catch rate reported in this study had fallen by 38% from the rate in a similar study conducted in 1984–86 (although this figure was not statistically significant).

Crocodiles

QPWS has monitored estuarine crocodiles (*Crocodylus porosus*) since 1979; over 220 vessel-based spotlight surveys were conducted between 1996 and 2002. Results indicate that the population of estuarine crocodiles is gradually recovering, particularly in remote areas of Cape York Peninsula and the Gulf of Carpentaria (Read, M., pers. comm.). The wild population is biased towards smaller immature crocodiles, which is consistent with a population in recovery. Another survey conducted by QPWS between 1996 and 1998 found 146 crocodiles in 346 km of waterways between Tully and Cooktown. The relative density ranged from 0.11/km to 1.00/km which, relative to Cape York, is low, and it is thought to result from the impacts of human activity (Kofron and Smith 2001).

Mammals

Whales

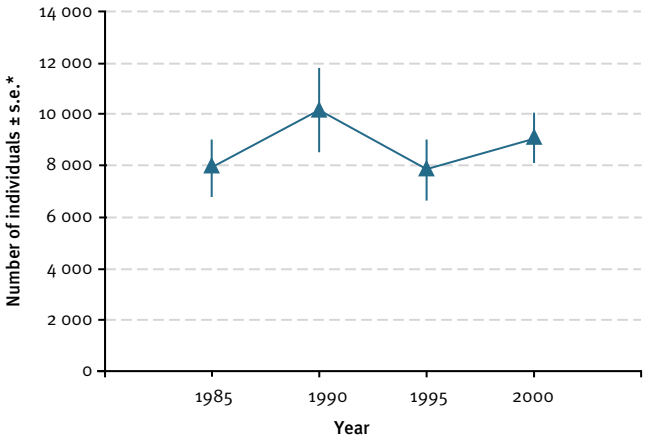
The east coast population of humpback whales is gradually recovering from a low point of about 500 in 1963 to approximately 4000 in 1998. This figure is roughly 40% of the pre-whaling level, although it is likely to be revised as historical population figures are adjusted to reflect new information about a large number of whales taken illegally in the late 1950s. Notwithstanding, the population continues to increase at an annual rate estimated to be between 3.9% and 11.7%. There is no evidence that commercial whale watching has affected the rate of recovery (Vang 2002).



The humpback whale population is recovering. (Photo: P. Candlin, EPA)

Dugong

An aerial survey in the northern section of the Great Barrier Reef in 2000 (Marsh and Lawler 2002) estimated that there were 9081 ± s.e. 917 dugong, establishing that the population has been relatively stable since 1985 (figure 6.32), temporal variations in local distribution being explained partially by long-distance migration. Population estimates from a 1999 survey in the southern Great Barrier Reef (3993 ± s.e. 641) and in Hervey Bay (1682 ± s.e. 236) were significantly higher than counts in 1995, but were not different from a survey in 1986–87 (Marsh and Lawler 2001). Again, the change in this population cannot be accounted for solely by natural increase, and it is postulated that a large number of dugong migrated south from the northern region of the Great Barrier Reef.



*s.e. = statistical error

Figure 6.32 *Dugong population trend in the Great Barrier Reef*
Source: Marsh and Lawler 2002

While these studies show a stable population over the period 1985–2000, additional evidence suggests that dugong numbers have declined dramatically over a longer period. Analysis of records of dugong caught in shark nets at eight areas along the east coast of Queensland (from Cairns to the Gold Coast) indicates that by 1999 the population had fallen by around 97% of the 1962 population levels (Marsh et al. 2002).

The use of differing methodologies has made it difficult to establish population trends in the dugong population of Moreton Bay. The first aerial survey in 1988 reported a population of approximately 460 dugong. Population estimates from later studies range from about 850–1000 in January 1995 (Lanyon in press), to 344 in December 2000. Dugong numbers fluctuate seasonally as the animals leave Moreton Bay in cooler months to seek warmer waters nearby (Marsh et al. 2002). A marking and recapture program was begun in 2001 to examine long-term population dynamics and life histories (Lanyon et al. 2002).

The dugong's food source of seagrass was diminished in Moreton Bay in 2000 when an area of 38 km² was overgrown by the cyanobacterium *Lyngbya majuscula*. This was associated with 20 dugong deaths, the largest number of deaths recorded in Moreton Bay since monitoring began in 1996 (Haines and Limpus 2000). Continued mortality at this rate would lead to a population decrease, given that a calculated 9–18 deaths annually is all that can be sustained by the Moreton Bay population (Lanyon in press).

Birds

The development by QPWS of the *Coastal Bird Atlas* for Queensland, with over 37 000 records, provides a centralised data source that has increased knowledge of coastal bird life, particularly seabirds and waders (White, R., pers. comm.).

Waders

Assessment of waders in Queensland is continuing. A number of studies are being conducted in various parts of the state, although the results of all of these are not available. Many waders found in the Queensland coastal zone are migratory, travelling between east Asia and Australia. A survey in the Gulf of Carpentaria shows that it holds more than half of the migratory waders that occur in Queensland (Driscoll 2001). The route taken by these birds, the East Asian-Australasian Flyway, is considered to be one of the most threatened of the world's flyways.

Under criteria in the Ramsar Convention, a wetland should be considered internationally important if it regularly supports 20 000 or more waterbirds or if it regularly supports 1% of the individuals in a population of one species or subspecies of waterbird. At least 16 species of wader birds have at least 1% of their flyway population in the south-east region of the Gulf of Carpentaria and five species have populations of over 20 000 (Driscoll 2001), so there appear to be sufficient grounds for the nomination of the area as a Ramsar site.

Preliminary data from an aerial survey in the Mackay region in 2002 revealed in excess of 10 000 waders, with large counts of eastern curlew, whimbrel and great knot. Grey plovers were also present in high numbers, compared with those in south-east Queensland (WA 2003). Counting in the south-east of the state has revealed no major changes in numbers of waders, although more recent figures than those given in 1999 (EPA 1999a) are yet to be published (Miller, G., pers. comm.).

Seabirds

Collection and collation of data for the *Coastal Bird Atlas* for Queensland have provided additional knowledge of seabirds—shearwaters, gulls, boobies, terns, cormorants and frigatebirds—in the state, particularly of their distribution. However, regular long-term census data are required to assess population dynamics, and quality data are available for only a limited number of species and colonies. Seabird census data vary in terms of area studied, regularity of collection and methods used.

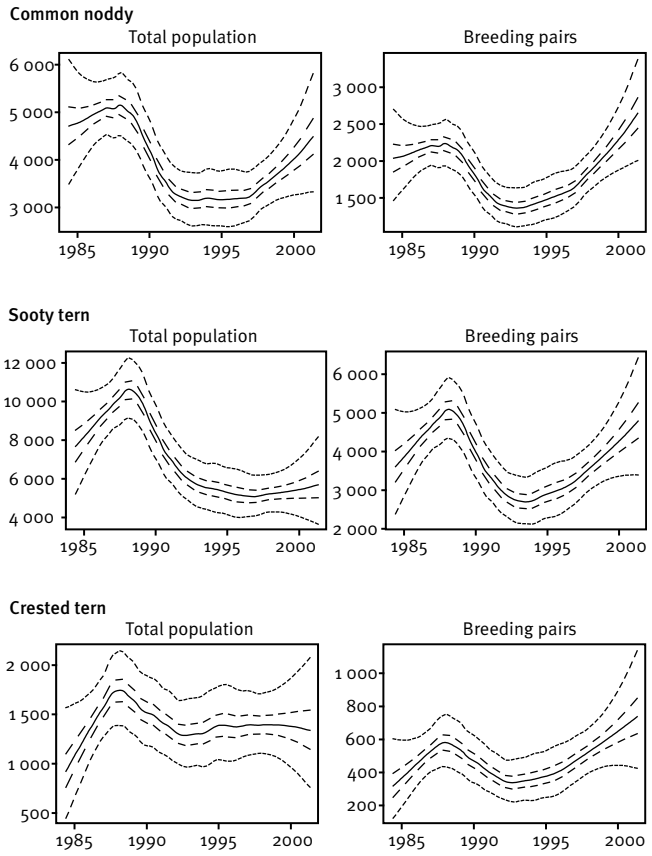


Figure 6.33 *Population trends of the common noddy, the sooty tern and the crested tern at Michaelmas Cay, 1984–2001. Dashed lines indicate 90% confidence intervals for individual trips (short dashes) and yearly moving averages (long dashes). Source: De'ath 2001*

Surveys since 1999 have revealed greater populations of some species of seabirds than were previously detected, islands off the Queensland coast now being estimated to be home to more than 1 314 000 breeding pairs of seabirds (table 6.32). More than 25% of Australia's tropical seabirds nest on the Great Barrier Reef.

Through banding and recapture, a survey in the summer of 2002 revealed that about 60% of the non-breeding roseate terns (*Sterna dougallii*) found in the Swain Reefs were of Japanese or Chinese origin. Very few were local, and the origin of the other 40% remains unknown, possibly being northern Australia, the Philippines or New Caledonia. Low recapture rates indicate that the overwintering area for roseate terns on the Great Barrier Reef may also include northern islands east of Cape York. The data suggest that the Great Barrier Reef non-breeding population of roseate terns may be much larger than current estimates, and represent a significant increase in the world population estimate (O'Neill and White 2003b).

New data for seabirds in Michaelmas Cay show recovery in populations of the common noddy (*Anous stolidus*) and the sooty tern (*Sterna fuscata*), as well as the crested tern (*Sterna bergii*), reversing the trend reported in 1999 (De'ath 2001)(figure 6.33). Overall bird numbers have increased since surveys in 1984 and 1996 in all categories measured (total populations, breeding pairs, fully fledged young and unpaired adults). The exceptions are in the total population of the sooty tern, which, while unchanged from 1996, remains below the 1984 population, and in the number of fully fledged young common noddies, which is also below 1984 levels.

Seabird data for the Gulf of Carpentaria remain patchy. With few surveys completed in the Gulf, populations may be significantly underestimated. Revised estimates from a field study conducted in November 2002, yet to be published, put the number of breeding pairs of roseate terns upward to 10 000 (O'Neill, P. and Elder, R., pers. comm.).



Seabirds, Bribie Island (Photo: L. Knight, EPA)

Table 6.32 Estimated number of breeding pairs of seabird species recorded on islands within the Great Barrier Reef region, the Coral Sea and the Gulf of Carpentaria, 2003

Common name	Scientific name	Number of breeding pairs		
		Great Barrier Reef	Coral Sea	Gulf of Carpentaria
Black noddy	*Anous minutus*	264 898	78 947	0
Common noddy	*Anous stolidus*	59 171	39 912	0
Lesser frigatebird	*Fregata ariel*	2 447	6 496	3 870
Great frigatebird	*Fregata minor*	47	5 938	0
Caspian tern	*Hydroprogne caspia*	67	na	50
Silver gull	*Larus novaehollandiae*	1 152	na	142
Australian pelican	*Pelecanus conspicillatus*	599	na	200
Red-tailed tropicbird	*Phaethon rubricauda*	106	398	0
Herald petrel	*Pterodroma arminjoniana*	3	na	0
Black-winged petrel	*Pterodroma nigripennis*	1	na	na
Wedge-tailed shearwater	*Puffinus pacificus*	310 836[a]	99 417	0
Little tern	*Sterna albifrons*	1 217	27	2
Bridled tern	*Sterna anaethetus*	50 237	2	Common
Lesser crested tern	*Sterna bengalensis*	32 351	na	50
Crested tern	*Sterna bergii*	45 575	516	13 471
Roseate tern	*Sterna dougallii*	17 293	na	10 000[b]
Sooty tern	*Sterna fuscata*	48 000	161 283	na
Black-naped tern	*Sterna sumatrana*	8 684	498	Common
Masked booby	*Sula dactylatra*	3 010	2 105	0
Brown booby	*Sula leucogaster*	24 712	5 900	5 400
Red-footed booby	*Sula sula*	658	9 169	0
Total		**870 729**	**410 608**	**33 190**

[a]Unpublished report to QPWS by Dyer and O'Neill on population size and distribution of wedge-tailed shearwater nests in the islands of the Capricorn and Bunker groups
[b]O'Neill, P. and Elder, R., pers. comm. following November 2002 field trip

Source: O'Neill and White 2003a

Responses

Government legislation and regulations, across all levels, provide a framework for protection of coastal habitat and biodiversity, setting out the types of activities that may be legally conducted along the coast. Alongside the legislative mechanisms are research programs, conducted by government agencies, universities, cooperative research centres and community groups, that build our knowledge of biodiversity. Education programs raise awareness of the issues, the pressures and the things people can do to protect coastal habitats and biodiversity. The involvement of Traditional Owners in management of biodiversity has been recognised at a Commonwealth level through the National Strategy for the Conservation of Australia's Biological Diversity (EA 1996) and the National Objectives and Targets for Biodiversity Conservation 2001–2005 (EA 2001b), and at a state level in a range of mechanisms aiming at development of joint management arrangements, which are discussed in Chapter 9, 'Natural and cultural heritage'.

Legislation and subordinate mechanisms that contribute to protection of the coastal zone are summarised below.

Commonwealth legislation includes:

- *Environment Protection and Biodiversity Conservation Act 1999*; and
- *Great Barrier Reef Marine Park Act 1975*.

State legislation includes:

- *Coastal Protection and Management Act 1995*;
- *Environmental Protection Act 1994*;
- *Integrated Planning Act 1997*;
- *Fisheries Act 1994*;
- *Marine Parks Act 1982*;
- *Meaker Trust (Raine Island Research) Act 1981*;
- *Nature Conservation Act 1992*;
- *Recreation Areas Management Act 1988*;
- *Tweed River Entrance Sand Bypassing Project Agreement Act 1998*; and
- *Wet Tropics World Heritage Protection and Management Act 1993*.

Under this range of legislation falls a range of regulations, policies, state planning policies, strategies and guidelines. The State Coastal Plan (EPA 2000) and proposed regional coastal plans provide an overarching mechanism for sustainable development in coastal areas, and the protection of habitat and biodiversity. At May 2003 draft regional plans had been released for public comment for three coastal regions: the Wet Tropical Coast, Cardwell–Hinchinbrook and Curtis Coast.

Codes of practice

Codes of practice are developed by government in consultation with industry groups to establish environmentally sustainable standards. A number directed at enhanced management of coastal and marine areas have been issued. They include codes for:

- Australian prawn farmers;
- crocodile farming; and
- commercial whale watching.

Four codes of practice are associated with permits issued for works in Queensland fish habitat areas. They include codes for:

- the control of mosquitoes in saltmarshes;
- local government infrastructure management;
- drain maintenance by cane growers; and
- the maintenance of powerlines.

Protection of coastal habitat

Various mechanisms exist for the protection of coastal habitat. These include designation of areas as World Heritage under the World Heritage program of the United Nations, Ramsar Wetlands listed under the Ramsar Convention, and state protected areas including marine parks, fish habitat areas, privately owned nature refuges, and species-specific areas, such as dugong protection areas (figure 6.35 and table 6.33).

While all mangroves are protected under the Fisheries Act, 12% of Queensland's mangroves fall within areas protected under the Nature Conservation Act (almost entirely national park). Six percent of Queensland's saltmarsh is protected. The Wet Tropics bioregion has the highest levels of protection, while the Gulf Plains has no protection for its wetland habitat (figure 6.34). The Southern Brigalow Belt has only a small amount of coastal wetland, none of which falls within protected areas.

Table 6.33 Summary of protected coastal areas in Queensland

Type of protected area	Number		Area (ha)		Notes
	At 2003	Change since 1999	At 2003	Change since 1999	
World Heritage Area	3	0	35 930 703	0	Inshore additions to the Great Barrier Reef Marine Park mean that it now incorporates 99.25% of the World Heritage Area.
Ramsar Wetlands	6	+1	2 361 914	+1 729 700	The Coral Sea Reserves (off the coast of Queensland) were declared in 2002.
Marine parks	7	+1	5 240 310	+38 680	The Trinity Inlet/Marlin Coast Marine Park was declared on 5 December 2001.
National parks	94	−4	1 790 080	+30 240	The number of parks was reduced owing to amalgamation of Rocky Islets, Northeast Island, Nymph Island, South Island and Two Islands national parks with adjacent parks. A new park, Percy Islands National Park, was gazetted in 2001.
Fish habitat areas	74	−5	714 000	+116 000	The increase in total area of fish habitat resulted from one new declaration as well as improved mapping using digital technology. The reduction in total number resulted from amalgamation of existing areas.
Dugong Protection Areas Zone A	8	0	414 410	0	
Dugong Protection Areas Zone B	8	0	197 680	0	

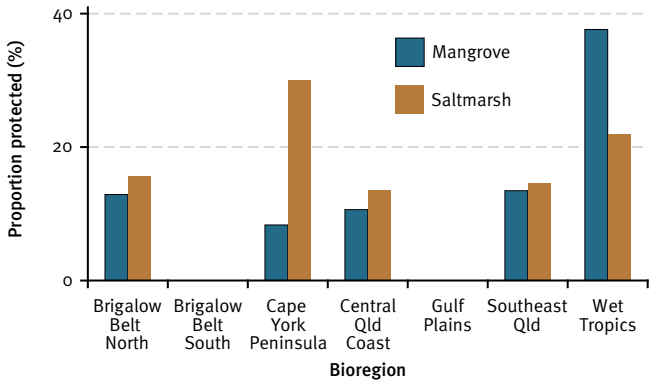


Figure 6.34 *Protection of mangroves and saltmarsh in Queensland's bioregions at December 2002*
Sources: DPI; EPA



Dwarf minke whale (Photo: Tourism Queensland)

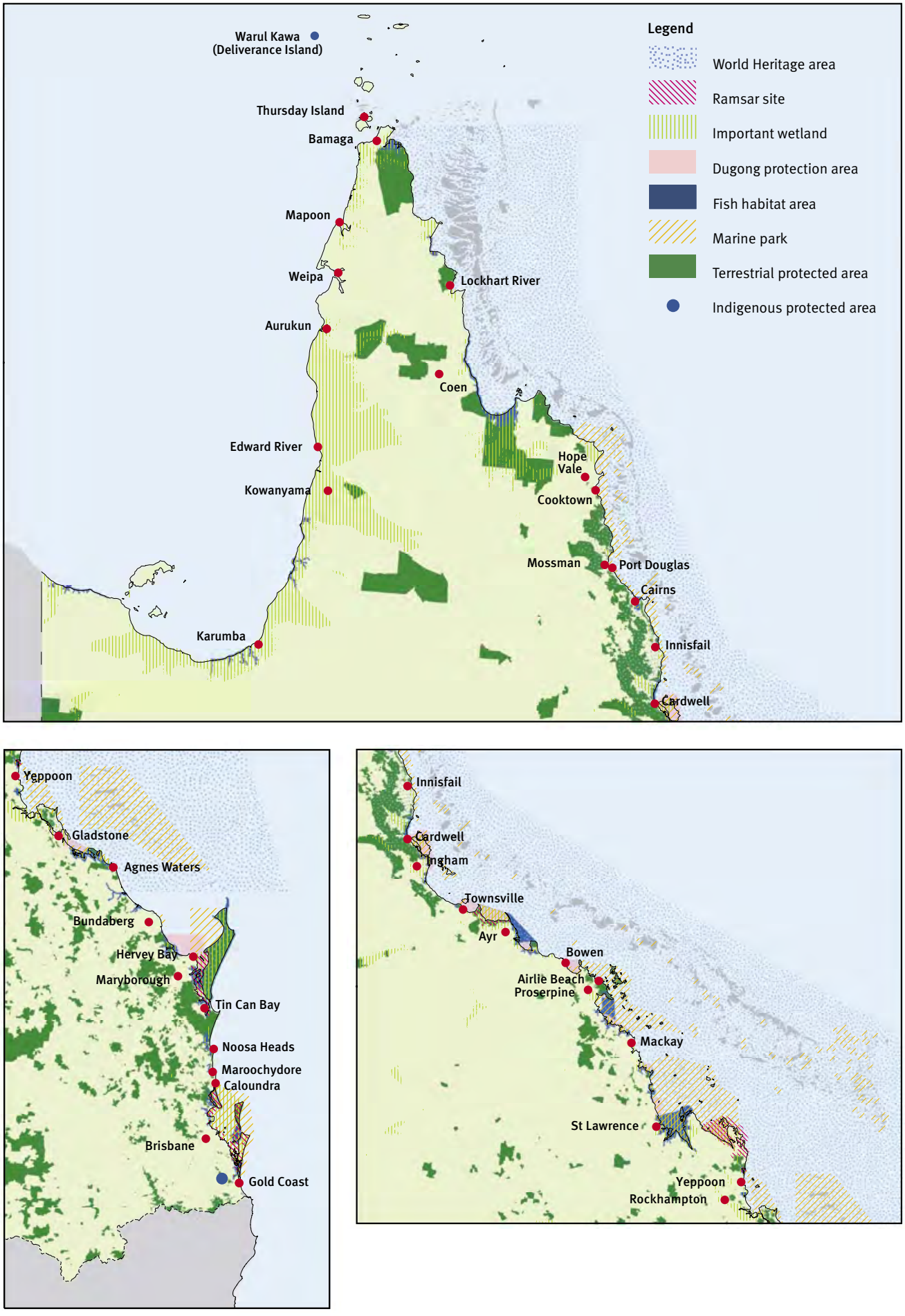


Figure 6.35 *Protected areas in Queensland*
Source: EPA

World Heritage Areas

The listing of World Heritage Areas in Queensland remains unchanged since 1999. Three sites are wholly or partially in the coastal zone: the Great Barrier Reef, Fraser Island and the Wet Tropics. These have been listed for their natural values; the Great Barrier Reef and the Wet Tropics meet all four criteria for listing (table 6.34), while Fraser Island is listed under categories (ii) and (iii). Under the international convention the Commonwealth Government commits itself to these sites' protection, conservation, presentation and transmission to future generations (see Chapter 9, 'Natural and cultural heritage').

Table 6.34 Natural values criteria for World Heritage listing

i	be outstanding examples representing major stages of earth's history, including the record of life, significant ongoing geological processes in the development of landforms, or significant geomorphic or physiographic features
ii	be outstanding examples representing significant ongoing ecological and biological processes in the evolution and development of terrestrial, freshwater, coastal and marine ecosystems and communities of plants and animals
iii	contain superlative natural phenomena or areas of exceptional natural beauty and aesthetic importance
iv	contain the most important and significant natural habitats for in-situ conservation of biological diversity, including those containing threatened species of outstanding universal value from the point of view of science or conservation

Source: UNESCO 2002

Great Barrier Reef Marine Park

The Great Barrier Reef Marine Park is managed by a statutory authority, the Great Barrier Reef Marine Park Authority (GBRMPA), established under Commonwealth legislation. The management of the park is achieved through a cooperative arrangement between the Commonwealth and Queensland governments.

In 2000 and 2001 an additional 28 inshore areas were added to the Great Barrier Reef Marine Park, extending the park into areas that were previously excluded because of their potential for port or industrial development. Under GBRMPA's representative areas program, rezoning to establish greater protection of the reef's biodiversity is planned through extension of the 'no-take' zones beyond the current level, which covers less than 5% of the marine park. As of April 2003, public submissions are being analysed in the development of a new zoning plan.

Coral reef protection

Threats posed by the crown-of-thorns starfish (COTS) and coral bleaching are being monitored and managed by GBRMPA. Due to the limited capacity for control measures and the natural role that COTS play in the reef ecosystem, management attention is focused on regulating the possible human causes of the outbreaks, such as poor land use practices. GBRMPA implemented the world's most comprehensive survey of coral bleaching in collaboration with the Australian Institute of Marine Science, Reef Cooperative Research Centre and US National Oceanic and Atmospheric Administration. Aerial surveys, in-water coral bleaching surveys and sea surface temperature mapping provided important information on the extent and severity of the 2002 bleaching event. This information will be used to further GBRMPA's knowledge of coral bleaching and assist in management decisions that may aid in the recovery and persistence of reefs affected by bleaching. Should warm water events increase in severity, duration or frequency in the future, coral bleaching is likely to become increasingly severe on the Great Barrier Reef.

State marine parks

The declaration of the Trinity Inlet/Marlin Coast Marine Park in 2001 brings the total number of marine parks in Queensland to seven (table 6.33). Like the Great Barrier Reef Marine Park, Queensland's state marine parks are zoned, with permissible activities defined for each zone. These range from preservation zones, which cover 0.2% of Queensland's marine parks, to general use zones (in which fishing and trawling are permitted), which cover 73.1%. (table 6.35). Under a draft planning framework for marine protected areas in Queensland (EPA 2000), the development of marine park coverage to achieve comprehensive, representative and adequate representation of marine areas is envisaged. The development of sub-bioregion mapping of coastal ecosystems is a prerequisite for this process to advance, but as yet this has been undertaken for only the Great Barrier Reef.

Table 6.35 Zonings as a percentage of state marine park area

Zone type	Percentage of state marine park area
Preservation	0.2
National park	2.9
Buffer	0.2
Conservation park	1.9
Estuarine conservation	0.2
Habitat protection	21.5
General use	73.1

Source: EPA 2000

Fish habitat areas

Fish habitat areas have been declared throughout coastal Queensland to enhance existing and future fishing activities and protect the habitat upon which fish and other aquatic fauna depend. Fish habitat areas protect critical wetland habitats which sustain the fish and invertebrate (prawn, crab, worm and shellfish) stocks upon which the commercial, recreational and Indigenous fishing and aquaculture sectors depend. Legal methods of taking fish and invertebrates for food or as bait are not restricted in fish habitat areas, except for worm digging.

DPI's Fish Habitat Areas (FHA) program started in the late 1960s. By 1995, 79 FHAs had been established, covering about 603 000 ha of tidal wetlands (Zeller and Beumer 1996). Following a review of boundaries and digital spatial data, the area protected in 2002 exceeded 714 000 ha.

Statewide analysis of the FHA network shows that it contains 37% of Queensland's estuaries, 42% of the mangrove habitat on the east coast and a significant proportion of the state's saltmarsh habitats, and includes representation of many natural shoreline habitat types (McKinnon et al. in press).

Analysis by IMCRA bioregions shows that more than 80% of the total area of tidal fish habitats protected by FHAs is located on the east coast in the three coastal bioregions between Lucinda and the New South Wales border (figure 6.36). A significant level of protection of wetland habitats found in estuaries (›30%) is also provided by fish habitat areas along the entire Queensland east coast. The percentage of estuaries protected by fish habitat areas in the Gulf of Carpentaria is lower, but reflects lower pressures for major coastal development across the West Cape York, Karumba–Nassau and Wellesley bioregions (McKinnon et al. in press).

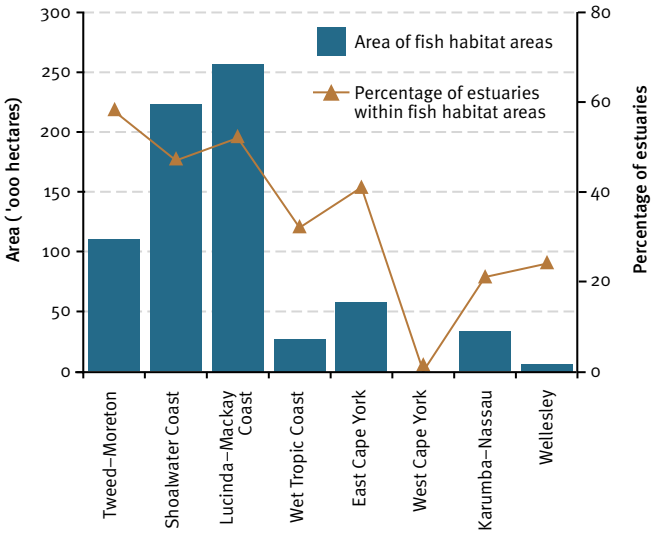


Figure 6.36 *Total area of tidal habitat and percentage of estuaries within fish habitat areas*
Source: McKinnon et al. in press

Wetlands program

Australia has committed itself to the protection of wetlands under the Ramsar Convention. Following the addition of the Coral Sea Reserves in 2002, five of the six wetlands of international significance listed for Queensland are in coastal or marine areas (see Chapter 9, 'Natural and cultural heritage').

Of the wetlands listed in the directory of important wetlands (EA 2001a), 26% fall within protected areas (table 6.36).

Table 6.36 Percentage of coastal zone wetlands listed in the Directory of Important Wetlands protected under the Nature Conservation Act or the Fisheries Act (excluding the Great Barrier Reef wetland), December 2002

Bioregion	Fish habitat area	National park	National park and fish habitat area	Other*	Not protected
Southeast Queensland	14	30	1	0	54
Brigalow Belt North	36	6	0	0	58
Wet Tropics	18	19	2	0	61
Central Queensland Coast	29	3	1	4	64
Cape York Peninsula	10	8	4	1	77
Gulf Plains	2	0	0	0	98
Queensland	**15**	**10**	**1**	**0**	**74**

*Includes state forest, nature reserves and timber reserves or combinations of these with fish habitat areas.

Source: EPA

Estuaries

An assessment of Queensland's 312 estuaries shows the varying levels of disturbance (naturalness) and diversity along with the international significance, as assigned by listing under international conventions (World Heritage and/or Ramsar), and levels of protection (table 6.37) (Page and Hoolihan 2002). The level of protection is determined by assessing the level of protection assigned to the estuary itself and to the land surrounding the estuary. The high levels of naturalness of estuaries in the Gulf of Carpentaria are afforded little protection by either state or international conventions.

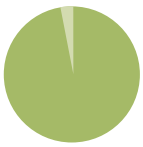
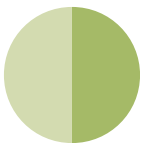
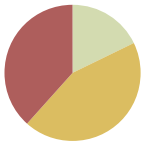
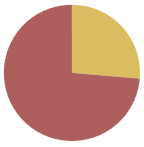
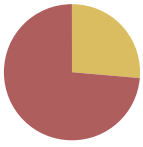
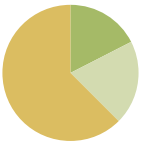
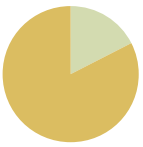
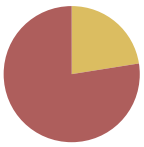
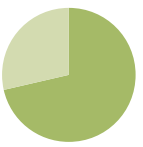
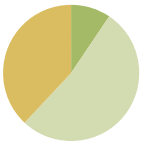
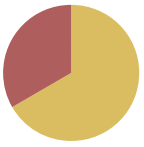
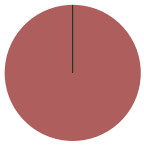
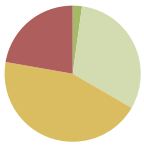
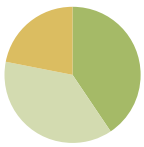
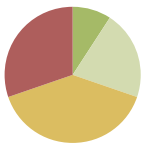
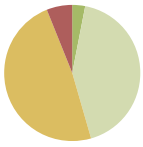
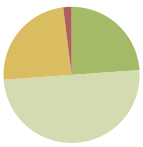
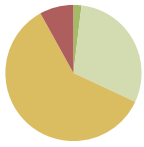
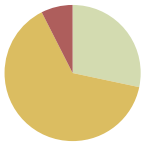
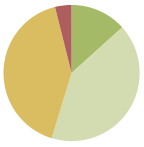
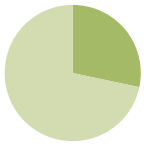
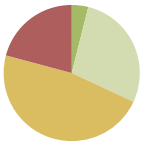
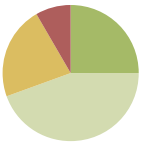
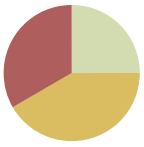


Fish habitat areas include 42% of the mangrove habitat on the east coast of Queensland. (Photo: EPA)

Listing of coastal species

Listing of threatened species occurs at international, national and state levels. The International Union for Conservation of Nature and Natural Resources (IUCN) maintains a database of threatened species (the Red List). At the national level, the *Environment Protection and Biodiversity Conservation Act 1999* lists threatened species, while in Queensland the listing of species occurs under the *Nature Conservation (Wildlife) Regulation 1994*. There is also a list of marine species under the *Fisheries Act 1994*.

Table 6.37 Summary of the ecological value of Queensland's estuaries and their level of protection. Ratings are given as proportion of the total number of estuaries within the marine bioregion.

Bioregion	Number of estuaries	Estuary naturalness	Drainage basin naturalness	Habitat diversity	International significance	Level of protection
Wellesley	34					
Karumba–Nassau	40					
West Cape York	21					
East Cape York	45					
Wet Tropics	33					
Lucinda–Mackay	50					
Shoalwater	53					
Tweed–Moreton	36					

Very high
High
Moderate
Low

Source: Page and Hoolihan 2002

Mammals

All marine mammals are protected by specific legislation. Dugongs are protected through the *Nature Conservation (Dugong) Conservation Plan 1999*, the *Recovery Plan for the Conservation of the* Dugong dugong *in Queensland 1999–2004* and amendments to the Fisheries Regulations.

Since the banning of whaling in Australian waters and protection of whales through state and Commonwealth legislation, the major threat to the recovery of the humpback whale is thought to be harassment resulting from poor tourism practices. To minimise this risk, commercial whale watching is regulated by a Nature Conservation Plan (EPA 1997).

In addition, a regulatory regime for swimming with dwarf minke whales, designed to reduce pressure resulting from tourism, has been implemented.

Another protective mechanism has been the establishment of a Marine Animal Hotline for the reporting of marine mammal and turtle strandings, to assist in animal recovery.

Birds

Of the twenty-two species of seabirds found in the Great Barrier Reef World Heritage Area, both the little tern (*Sterna albifrons*) and the herald petrel (*Pterodroma arminjoniana*) are listed as endangered and the red-tailed tropicbird (*Phaethon rubricauda*) is listed as vulnerable under Queensland's Nature Conservation Act. Under the Commonwealth's EPBC Act, the herald petrel is listed as critically endangered.

In the *Action Plan for Australian Birds 2000* (Garnett and Crowley 2000) the herald petrel is listed as critically endangered, the red-tailed tropicbird as near threatened, the masked booby (*Sula dactylatra*) as vulnerable, and the little tern as of least concern.

Migratory birds are the subject of three specific international agreements. The Japan–Australia Migratory Bird Agreement (JAMBA) was signed in 1981, while the China–Australia Migratory Bird Agreement (CAMBA) was entered into in 1986. Under these agreements, a total of 93 species of birds have been listed for protection (CAMBA 82, JAMBA 66). In 2001 the Agreement on the Conservation of Albatrosses and Petrels was signed by seven countries, Australia, Brazil, Chile, France, New Zealand, Peru and the United Kingdom; another two, Spain and Ecuador, signed subsequently.

Management of coastal birds requires adequate data about population size and nesting habits. The Coastal Bird Monitoring Strategy (Turner 2002) outlines the minimum monitoring requirements to collect these data.

A bird subspecies of great concern in the coastal zone is the yellow chat (dawson) (*Epthianura crocea macgregori*), listed as critically endangered under the EPBC Act. This subspecies is known from only a single location (estimated at 25 km²) on the marine plain of Curtis Island, with a maximum population estimate of 50 breeding individuals (Houston et al. unpublished).

Another species of concern in the coastal zone is the southern cassowary (*Casuarius casuarius johnsonii*). It occurs in three distinct populations, two on Cape York (listed as vulnerable), and a southern population ranging from Mossman to near Cardwell, which is listed as endangered. A recovery plan is being implemented (QPWS 2002).

Reptiles

The conservation status of the six marine turtles is unchanged since 1999 (table 6.38). The estuarine crocodile is still listed as vulnerable.

Fish

With growth in knowledge, it has been possible to assess the conservation status of some fish species. The Australian Society for Fish Biology (ASFB 2001) and Environment Australia, in the *Conservation Overview and Action Plan for Australian Threatened and Potentially Threatened Marine and Estuarine Fishes* (Pogonoski et al. 2002), have assessed the status of fish species against the IUCN conservation categories. Two species of estuarine and marine fish that occur in Queensland waters are listed as critically endangered; another eight are listed as endangered or vulnerable; and others are listed as being at various degrees of lower risk (table 6.39).



The grey nurse shark is an endangered species. (Photo: C. Bansemer, EPA)

Flora

The protection of terrestrial flora is discussed in Chapter 7, 'Biodiversity'. The Queensland Government has legislated for broadscale management through the *Vegetation Management Act 2000* and the *Nature Conservation (Protected Plants) Conservation Plan 2000*, which provides a framework for strategic management.

Table 6.38 Conservation status of marine turtles under Queensland and Commonwealth legislation, and under the IUCN Red List

Species	Common name	*Nature Conservation (Wildlife) Regulation 1994* (Qld)	*Environment Protection and Biodiversity Conservation Act 1999* (Cwlth)	IUCN Red List
Caretta caretta	Loggerhead turtle	Endangered	Endangered	Endangered
Chelonia mydas	Green turtle	Vulnerable	Vulnerable	Endangered
Dermochelys coriacea	Leatherback turtle	Endangered	Vulnerable	Critically endangered
Eretmochelys imbricata	Hawksbill turtle	Vulnerable	Vulnerable	Critically endangered
Lepidochelys olivacea	Olive ridley turtle	Endangered	Endangered	Endangered
Natator depressus	Flatback turtle	Vulnerable	Vulnerable	Data deficient

Sources: EPA; EA; IUCN

Table 6.39 Conservation status of fish species found in Queensland and listed in the Conservation Overview and Action Plan for Australian Threatened and Potentially Threatened Marine and Estuarine Fishes

IUCN conservation status	Common name	Scientific name
Critically endangered	Speartooth shark Freshwater sawfish	*Glyphis* sp. A *Pristis microdon*
Endangered	Grey nurse shark Dwarf sawfish Green sawfish	*Carcharias taurus* *Pristis clavata* *Pristis zijsron*
Vulnerable	Great white shark Colclough's shark Narrow sawfish Freshwater whipray Black rockcod	*Carcharodon carcharias* *Brachaelurus colcloughi* *Anoxypristis cuspidata* *Himantura chaophraya* *Epinephelus daemelii*
Lower risk (conservation dependent)	School shark Barramundi cod Queensland grouper Potato cod Eastern blue devil Eastern blue groper Humphead maori wrasse	*Galeorhinus galeus* *Cromileptes altivelis* *Epinephelus lanceolatus* *Epinephelus tukula* *Paraplesiops bleekeri* *Achoerodus viridis* *Cheilinus undulatus*
Lower risk (near threatened)	Dusky shark Sandbar shark Estuary stingray Porcupine ray Sculptured frogfish Bighead seahorse Low-crown seahorse Bluefish Ballina angelfish Southern bluefin tuna	*Carcharhinus obscurus* *Carcharhinus plumbeus* *Dasyatis fluviorum* *Urogymnus asperrimus* *Halophryne queenslandiae* *Hippocampus grandiceps* *Hippocampus dahli* *Girella cyanea* *Chaetodontoplus ballinae* *Thunnus maccoyii*
Lower risk (least concern)	Australian handfish Banded pipefish Estuary rockcod Purple rockcod Flowery cod Malabar grouper Camouflage grouper Greasy grouper Elegant wrasse	*Brachionichthys* sp. *Dunckerocampus dactyliophorus* *Epinephelus coioides* *Epinephelus cyanopodus* *Epinephelus fuscoguttatus* *Epinephelus malabaricus* *Epinephelus polyphekadion* *Epinephelus tauvina* *Anampses elegans*

Source: Pogonoski et al. 2002

Community

Community participation in research and education programs, as well as non-government organisations advocating for environmental protection, has become a feature of Australian life, with many people joining conservation and environmental organisations. Many of these organisations are specifically concerned with the marine environment (such as the Australian Marine Conservation Society) or, in the case of larger organisations such as the World Wide Fund for Nature, have sections with a marine focus. Activities of community organisations include advocacy and lobbying, raising public awareness, and participation in conservation activities such as habitat rehabilitation. The Seagrass Watch program is an example of a successful community participatory activity in Queensland (see 'Seagrass Watch', page 6.73).

The Commonwealth Government also makes funds available to government and non-government organisations under its Coasts and Clean Seas program, as part of the Natural Heritage Trust. In 2000–01, a total of $2.76 million was allocated to 57 projects in Queensland, while $0.35 million was allocated to national projects, most of which will contribute to management of marine systems in Queensland (EA 2002b).

Data from the Australian Bureau of Statistics show that over the past decade concern for the environment has been dropping. In 2001, of the 7% of Australians who were members of environmental groups, 11% belonged to organisations that dealt with marine conservation (ABS 2003). The reasons for the decline in concern warrant further examination.

Research, monitoring and data coordination

Institutions that are contributing to the growth in knowledge of Queensland's marine habitat and biodiversity include universities, Cooperative Research Centres (CRCs) and other research organisations, as well as state government departments. Of the seven universities based in Queensland, five have specialist programs in environmental sciences and/or coastal and marine biology. Under the Commonwealth Government's CRC program, the CRC for the Great Barrier Reef World Heritage Area and the CRC for Coastal Zone, Estuary and Waterway Management deal directly with marine and coastal ecology. The CRC for Tropical Rainforest Ecology and Management also deals with rainforest in coastal ecosystems. The Australian Institute of Marine Science, the Great Barrier Reef Marine Park Authority, DPI's Northern Fisheries Centre and CSIRO conduct specialist research in marine ecology.

Queensland government agencies also conduct research to support the management of marine and coastal biodiversity. The lead agency for the environment is the Environmental Protection Agency, incorporating the Queensland Parks and Wildlife Service. Areas of investigation include a threatened species program, as well as biodiversity mapping. The Queensland Fisheries Service, within the Department of Primary Industries, is the key agency for management of fishing and fish habitat, long-term monitoring of fish stocks and the Web-based Coastal Habitat Resources Information System (CHRIS).

The case study 'Satellite sensors used to assess estuarine and marine health' (page 6.71) provides an example of research supporting management of coastal ecosystems.

Pest management programs

Ballast water and fouling pests

Actions at the international and national levels, along with the implementation of programs within Queensland ports, have reduced the risk of the introduction of pests through ballast water. Ballast water is released under the regulation of the Australian Quarantine and Inspection Service (AQIS) within the framework of Australia's Oceans Policy (EA 1998). The source of ballast water is also monitored, and mid-ocean exchange of ballast water is a recommended mechanism for lowering the risk of the introduction of exotic pests. It is prohibited to release ballast water assessed as high risk into Australian waters. The Australian Ballast Water Decision Support System, developed by AQIS, assists in the determination of the level of risk.



Surveys for particular pest species were undertaken in ports in Townsville, Brisbane and Gladstone (pictured). (Photo: EPA)

Port authorities in Queensland have conducted surveys for introduced species. No target pest species were found by the Port of Townsville, the Port of Brisbane or Port Curtis (Gladstone) in surveys conducted in 2000 and 2001. Other introduced species were detected, but are not considered to threaten native species (GPA 2002; PoT 2002; PoB 2002).

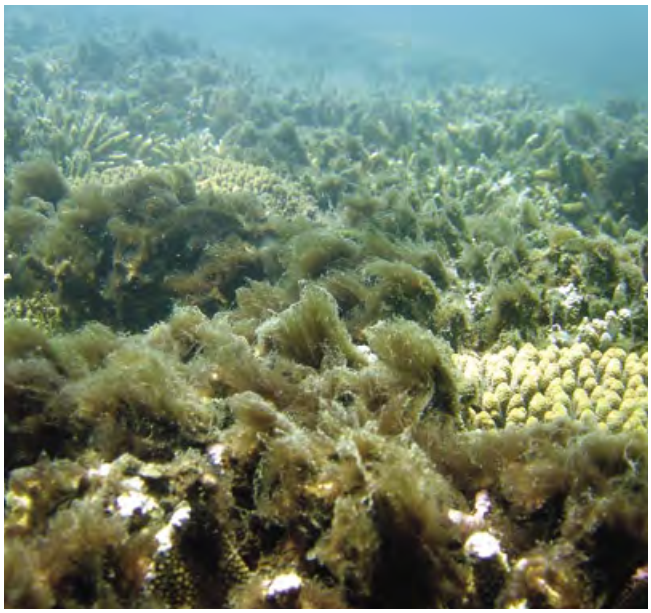
Weeds

Weeds are managed at various levels described in Chapter 4, 'Land'. Control strategies were published in 2001 or 2002 for nine of the ten weeds of national significance that occur in coastal Queensland (table 6.24), while a strategy for the tenth weed, salvinia, was nationally endorsed in 2002.

At a state level, the Department of Natural Resources and Mines develops strategies and control procedures for weeds. It also conducts research into control of weeds through chemical and biological means. In south-east Queensland, the environmental weeds strategy developed by the Environmental Weeds Working Group ranked 200 weeds according to threat as determined by the Queensland Herbarium (Batianoff and Butler 2002).

Lyngbya

In response to the outbreak of Lyngbya in Moreton Bay, the Lyngbya Steering Committee, part of the Moreton Bay Waterways and Catchments Partnership, published a management strategy in 2002 (MBWCP 2002). The strategy lists agreed management actions for dealing with the mitigation, investigation and catchment protection issues associated with Lyngbya blooms in Moreton Bay coastal waters, particularly in northern Deception Bay.



Lyngbya bloom, Moreton Bay (Photo: S. Albert)

COTS

Control of the crown-of-thorns starfish is problematic. Because the starfish occur naturally on the Great Barrier Reef, killing them is not recommended when they are present in low numbers. Once an outbreak is detected, however, controls are expensive and difficult to implement. Around some reefs visited regularly by tourists, localised control programs are conducted by divers, who inject the starfish with a sodium bisulfite solution.

Feral animals

Feral animals pose a threat to native wildlife in some coastal areas. Species facing particular threats include the cassowary and waders. Programs for control of feral animals are described in Chapter 4, 'Land' and Chapter 7, 'Biodiversity'. A specific problem is the presence at Mon Repos of foxes, which feed on turtle eggs laid by the endangered loggerhead turtle. In this case, fencing is used as a deterrent. Another example of feral animal control in the coastal zone is the Port Authority's trapping of cats and foxes at the Port of Brisbane to protect a population of wader birds.

Summary of condition and trend indicators

Coastal habitats and biodiversity

Indicator	Queensland
Disturbance of marine habitat	
Trawling	
Coastal habitats	▼
Ship arrivals from foreign ports and ballast water discharged to Queensland waters	
Visits (number)	▲
Pest surveys	▲
Ballast water control	▲
	Base data
Extent and diversity of estuarine, coastal and marine habitats	
Knowledge	▲
Condition	?
Number and area of known endangered ecosystems within each coastal region	
Mapping	▲
Number and area	Base data
Number of known significant wildlife sites by type	
Estimated wild fish stocks	?
Population trends for coastal species and/or habitat types listed as rare, threatened and endangered	
Dugong	▼
Loggerhead turtle	▼?
Green turtle	▼
Humpback whale	▲
Sooty tern	▲
Lineal extent of coastal watercourses supporting native riparian vegetation	X
Number and type of marine and terrestrial pest and displaced species identified as of concern in each coastal region	X
Area of coastal habitats by type (e.g. wetlands/dunefields etc.) afforded reserve status or equivalent (e.g. conservation covenant)	▲
Number of coastal species and/or habitat types listed as rare, threatened, endangered or recently extinct	Marine and estuarine fish data for first time
Number and type of pest species management programs undertaken	▲

Key to condition for coastal population growth:

- Good
- Moderate
- Poor
- Not assessed

Key to trend:

- ▼ Degrading
- ▲ Improving
- ? Not clear
- X Not assessed
- – No change

Case study: Satellite sensors used to assess estuarine and marine health

Coastal Cooperative Research Centre

The assessment and monitoring of the condition of Australian estuarine and marine environments are reliant upon assessment of key indicators. Water quality and benthic habitats are assessed by measuring indicators such as turbidity, suspended sediments, chlorophyll *a* and seagrass distributions. A major issue in the interpretation and application of these indicators is that they can vary significantly over small spatial and temporal scales. Current methods of measuring these indicators, such as field surveys, can significantly limit the coverage of data available for accurate assessments.

Researchers from the Coastal CRC, CSIRO and The University of Queensland have been exploring the utility of data acquired from satellites for assessing water quality and benthic habitat condition in Moreton Bay. The research team has identified the types of information required by monitoring and management agencies to analyse and monitor resource condition. Research is now directed at developing and applying algorithms to process satellite images so that changes in estuarine and marine environments that are related to ecosystem health and condition can be assessed.

Measuring water quality indicators of the whole bay at once enables spatial patterns to be detected more easily than they are in field surveys. The satellite image in figure 6.37 has been corrected for atmospheric and sun-angle effects. Bathymetric contours are overlaid on the true colour image. A large plume of water rich in organic matter is crossing Moreton Bay from west to east, as a result of a significant period of rainfall and river discharge in the period 2–10 February 2001. By assessing the changes in these patterns over time and different rainfall regimes, researchers can describe the magnitude and persistence of impacts from the catchment on Moreton Bay (Phinn et al. 2003).

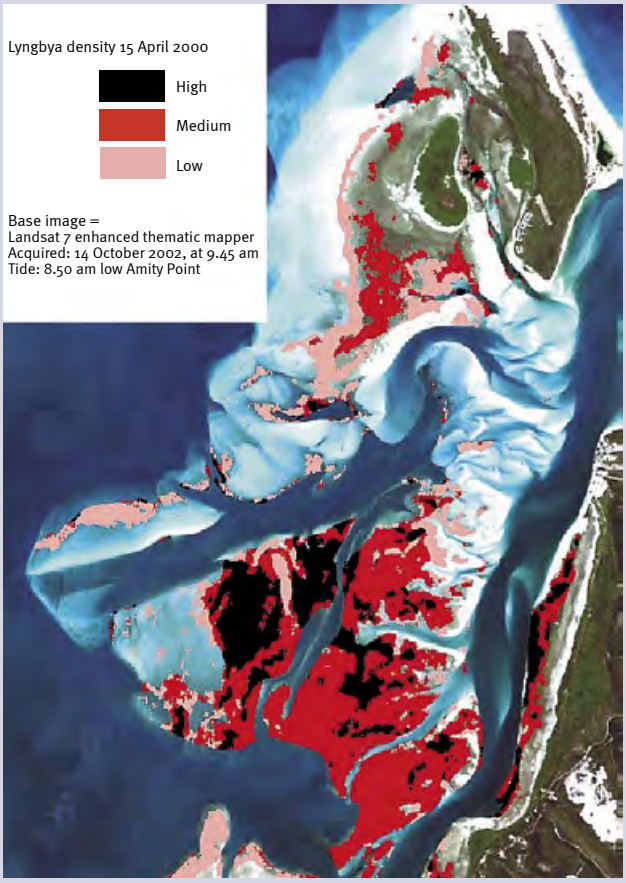


Figure 6.37 *Satellite image of Moreton Bay showing a plume of water rich in organic matter*
Sources: Landsat and Coastal CRC

Case study: Satellite sensors used to assess estuarine and marine health *(continued)*

Blooms of the marine cyanobacterium *Lyngbya majuscula* in Moreton Bay have occurred with increasing frequency in recent years, and are a concern because of the impacts they can have on ecological, economic and human health. The Coastal CRC researchers have developed and applied image processing algorithms for mapping Lyngbya in the optically complex coastal waters of Moreton Bay (Roelfsema and Phinn 2003). Figure 6.38 shows the distribution of Lyngbya blooms in the eastern Bay on 15 April 2000 and 11 July 2002. This information is used to provide regular updates on the extent of Lyngbya blooms in Moreton Bay via the Healthy Waterways website. To ensure that the new approaches are robust and accurate, they will be applied to a longer time series of satellite images and validated against field data collected throughout the Bay.

The remote sensing research team is currently working with monitoring and management agencies to develop suitable methods of delivery of remotely sensed data for key estuarine and marine indicators. The resultant mapping and interpretation procedures will be presented in a coastal remote sensing toolkit for use by coastal scientists and managers.



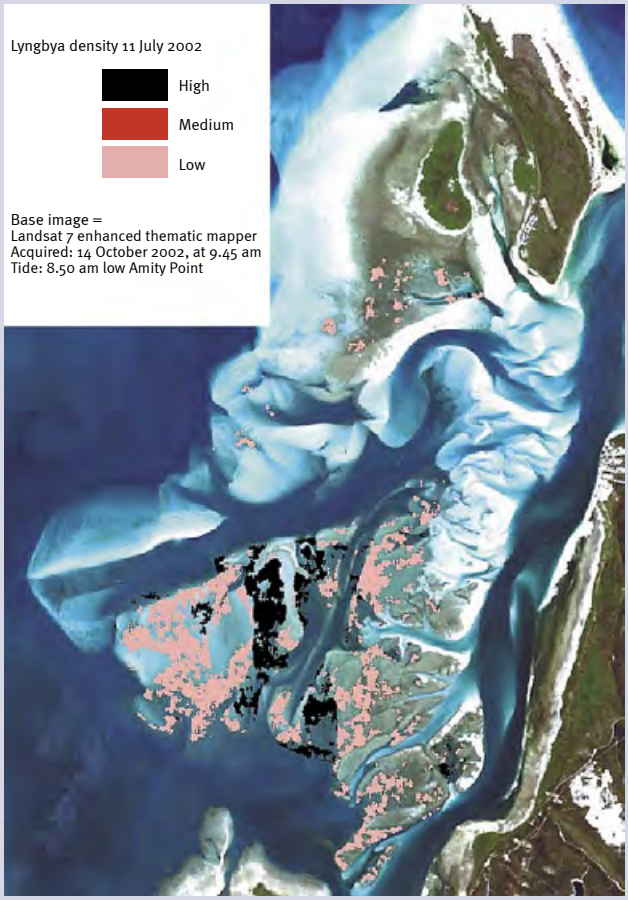


Figure 6.38 *Satellite images of Moreton Bay showing changing densities of Lyngbya*
Sources: Landsat and Coastal CRC

Case study: Seagrass Watch

Seagrass Watch is a community-based monitoring program developed by the Marine Plant Ecology Group at Queensland's Department of Primary Industries in conjunction with the Natural Heritage Trust, CRC Reef, Queensland Parks and Wildlife Service, Coastcare and community organisations. The program assesses the health of nearshore seagrass habitats throughout Queensland, provides an early warning of major changes in seagrass habitats and assists in the development of management actions.

Seagrass Watch programs have been established at about 60 sites in five regions in Queensland (Hervey Bay/Great Sandy Strait, Whitsundays, Townsville, Cairns and Moreton Bay) and involve more than 500 volunteers and government workers. The program incorporates local community groups, schools, TAFE colleges, universities and government agencies. Community members involved in Seagrass Watch have become powerful advocates for the sustainable protection of fisheries habitats, are represented on local management committees and provide numerous educational sessions to industry groups, communities, schools, and Indigenous students. The program is also being developed in the Western Pacific, with an emphasis on exporting excellence in training and scientific services.

Volunteers have been trained in scientific protocols to assess the health of seagrass meadows. All data collected are entered into a database and results are presented in newsletters and reports. Seagrass Watch has assisted with assessment of dredging activities, coastal developments, sewage outfalls, boating damage and algal blooms. Information collected contributes directly to marine park planning and provides information for assessing management actions and catchment practices.



Dugongs and the green turtle feed on seagrass meadows. (Photo: EPA)

Challenges of the program include retraining of community participants, recruitment and training of new participants, and communication of findings to management agencies. The aim of achieving better environmental management through the integration of Seagrass Watch data with information from other monitoring programs (water quality data, oceanographic data, climate data, turtle and dugong research programs) provides a challenge for government agencies and communities to work together constructively.

Coastal variability – physical processes

Summary

Open coastlines play an important role in providing a buffer between the land and the ocean. They dissipate wave energy and protect the land and the infrastructure on it from the effects of coastal hazards such as storm tides, cyclones and flood inundation. A key characteristic of Queensland's shoreline is its constantly changing condition through natural fluctuations caused by erosion, accretion and coastal hazards. Problems arise when these natural fluctuations affect private land or coastal structures built too close to the beach.

The ideal way to manage beaches is to allow shorelines to fluctuate naturally. This is only possible if a sufficient undeveloped foreshore buffer zone exists. When the buffer zone does not provide adequate protection, other solutions are necessary.

Description

The way that shorelines and beaches respond to differences in wave energy, tidal energy, sediment type and sediment supply helps explain the differences in Queensland's coastline. At any one time and place a given set of wave and tidal conditions can transport a given amount of sediment. If the supply of sediment to a specific system is greater than the ability of the waves or tide to transport it, beach accretion occurs; if the wave or tidal energy available to transport sediment is greater than the supply, erosion occurs. Beach conditions fluctuate naturally according to prevailing conditions and contribute to the natural variability of the open coastline. Accretion and erosion cycles tend to cancel each other out over long periods.

Tidal entrances where rivers, estuaries and embayments connect to the ocean are a significant feature of open coastlines. In their natural state, tidal entrances influence the transport of sediment along the open coastline: the entrances trap sediment, and downdrift beaches are not replenished. As natural tidal entrances are shallow and are often broad, the location of the main channel can migrate under the action of the prevailing wave and tidal conditions. Tidal entrances are often the sites of major population centres and associated infrastructure, so that any migration of the channel can have serious consequences. In these instances, rock structures (groynes) are often constructed to limit the channel migration.



Rock structures (groynes) are often constructed to limit channel migration at tidal entrances. (Photo: EPA)

Groynes and dredging help to maintain channel position in tidal entrances and reduce the amount of sediment that enters the inlet from the open coastline. Dredging also contributes to better tidal flushing in tidal entrances, which improves estuary water quality. Groynes have been shown to be partially effective in maintaining a navigational channel and promoting effective tidal flushing; however, additional dredging is usually required to maintain navigational depths.

The implication of these structures is that they stop the natural supply of sediment along the open coast. The result is often long-term recession of downdrift beaches, in some cases for many kilometres downdrift. Where this erosion influences beach amenity and threatens infrastructure, action is required to restore the coastal buffer zone. Long-term erosion can only be investigated by analysis of long-term trends.

Pressures

The major pressure on the functioning of open coastlines and tidal estuaries is the loss of natural buffer areas to coastal development. When development occurs in the zone where beaches could naturally manage the effects of erosion and coastal hazards, the pressure to construct structures to protect human life and property greatly increases.

Property protection structures, such as seawalls, groynes and artificial reefs, put pressure on natural coastal processes such as erosion and longshore drift. They stop or redirect the flow of sand from rivers and offshore areas, which is critical to the maintenance of beaches and foreshore areas. This causes the loss of sand from beaches, receding shorelines, loss of foreshore vegetation and increased risk associated with coastal hazards (EPA 2001).

Other pressures on open coastline and tidal estuaries include coastal hazards and the need to adapt to climatic changes. Coastal hazards include storm tides, cyclone effects and related inundation. Extreme events such as tropical cyclones are potentially highly destructive to the coastal zone. Commonly associated with cyclones is the phenomenon of storm surge, where the sea level rises above the normal level of the astronomical tide (Harper 1998). The combination of storm surge with astronomical tide is known as storm tide. Storm tides pose the greatest threat to human life and property on the coast.

Recent scientific research has found that the enhanced greenhouse effect will have an impact on global climate. Possible changes such as a rise in global mean sea level, higher average air and sea temperatures and increased climatic variability could have severe consequences for Queensland.

Condition and trends

In view of the dynamic nature of the beach environment, a summary statement on the overall condition of Queensland's beaches is not provided.

Conditions that are able to be measured include sea level, cyclone events and storm surge height.

The Queensland Government has recorded sea level at a network of storm tide monitoring gauges along the Queensland coast for around 20 years. Figure 6.39 shows the location of these gauges and sea level trends for a number of them. While all sites (with the exception of Cardwell) show a rising trend, the period of observation is too short to estimate long-term sea levels. The rising trend is supported by other studies conducted over longer periods by other organisations, notably the National Tidal Facility.

An analysis of cyclone activity in the Great Barrier Reef region between 1958 and 1992 has led to predictions that an annual average of two tropical cyclones will occur in the region during El Niño years. During La Niña years, cyclonic activity increases, and an annual average of about 7.5 tropical cyclones can be expected (Lough 1997). Figure 6.40 plots the annual occurrence of tropical cyclones in the Queensland region between 1910 and 2001 and the Southern Oscillation Index for the same period.



Figure 6.39(a) *Tide gauge locations*
Source: EPA

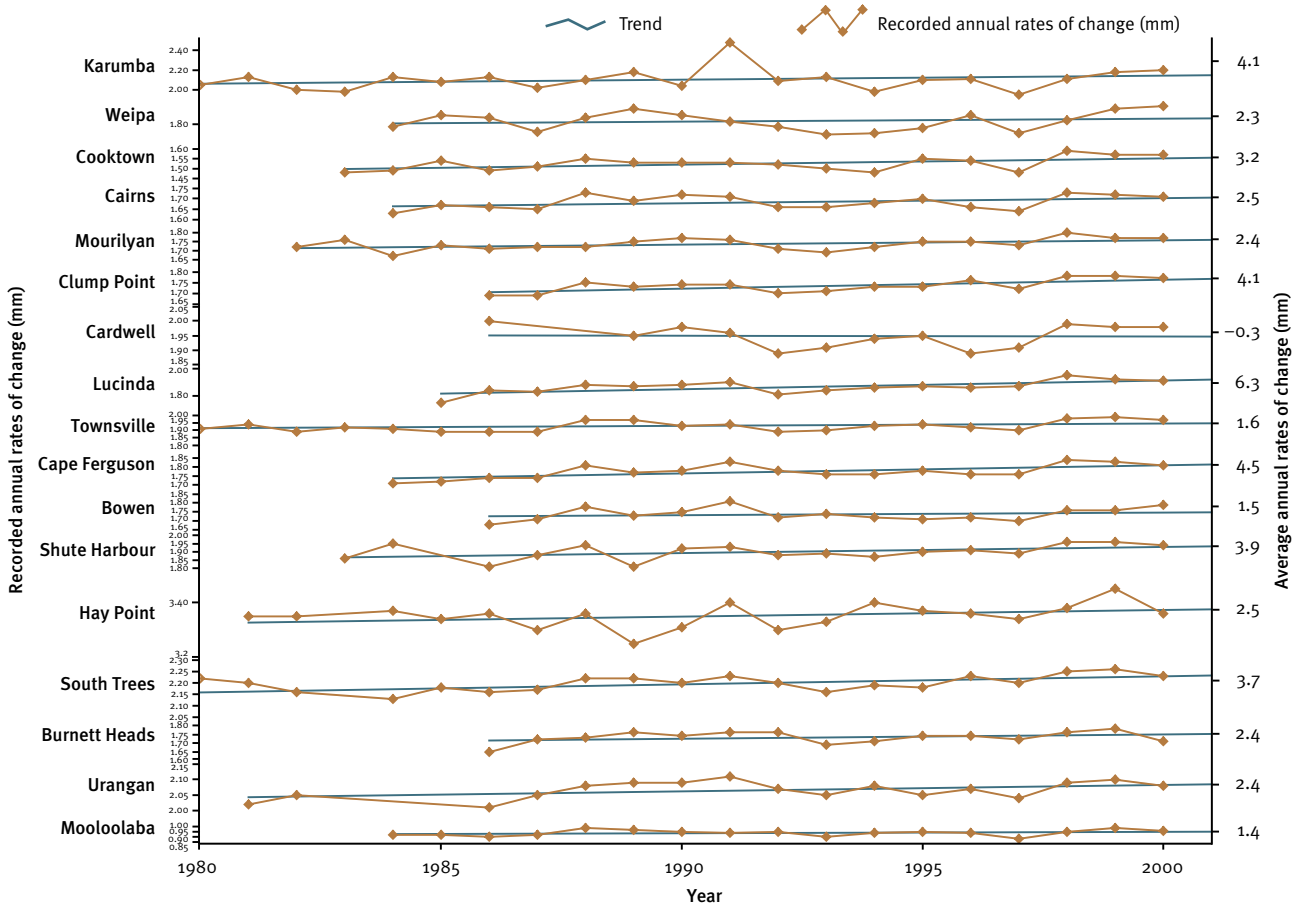


Figure 6.39(b) *Sea level trends at selected monitoring sites.*
Source: EPA

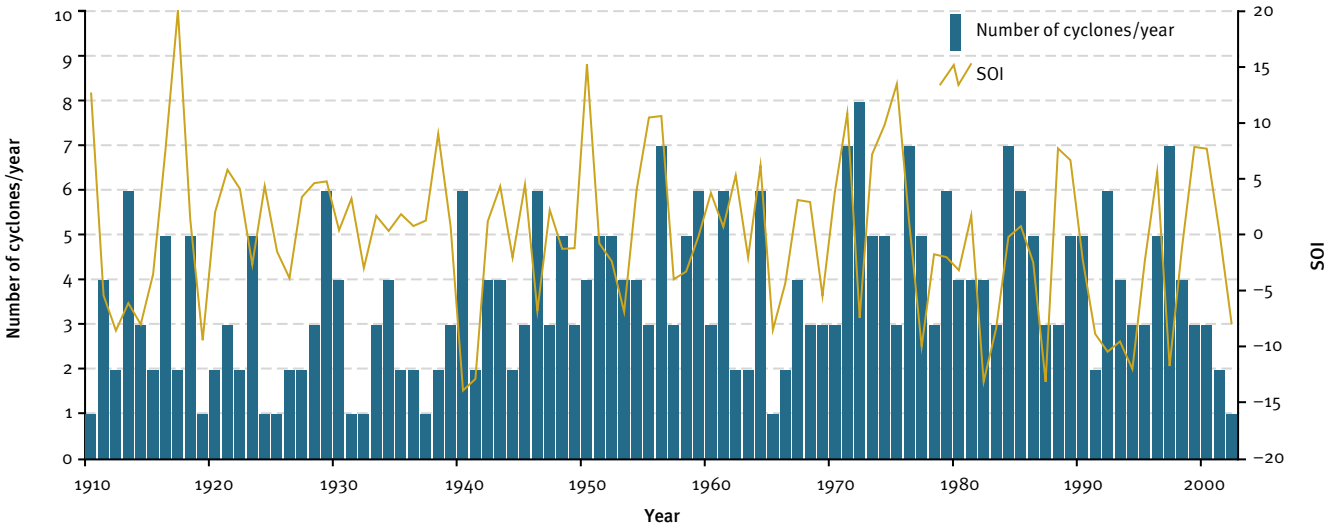


Figure 6.40 *Number of cyclones recorded each year in Queensland, 1910 to 2001. The use of satellite technology has improved the detection of and reliability of information about cyclone activity.*
Sources: Lourensz 1981; BoM

Figure 6.41 shows the occurrence of cyclones by region. Cyclone activity is clearly highest in north Queensland between 11°S and 18°S. In the period 1910–2002, 83 cyclones passed within the boundary of the EPA's Northern Region (one cyclone every 1.1 years); 51 cyclones passed within the EPA's Central Region (one every 1.8 years); and 27 cyclones passed within the EPA's Southern Region (one every 3.4 years). Table 6.40 shows the number of cyclones by category, and the number within each category that crossed the coast. These figures include cyclones that existed in more than one region.

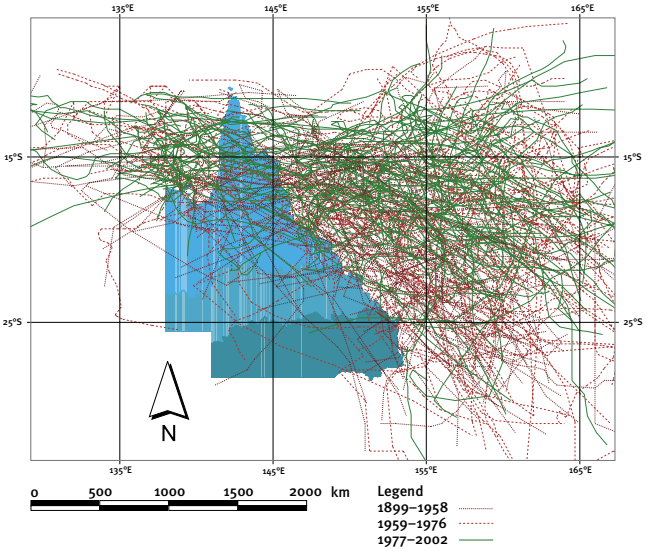


Figure 6.41 *This congested plot shows the tracks of tropical cyclones along the Queensland coast.*
Sources: Lourensz 1981; BoM; EPA

Table 6.40 Queensland cyclones, 1910–2002, by category

Category	0	1	2	3	4	5
Number of cyclones	24	181	70	62	18	2
Coast crossing	58	67	16	14	2*	0

*The two category 4 cyclones at the time of coast crossing both occurred in 1918.
Sources: Lourensz 1981; BoM; EPA



Elevated storm tide allowing waves to overtop Cairns northern beaches during tropical cyclone Justin, March 1997 (Photo: EPA)

Increased frequency and height of storm surges could be a result of climatic change; monitoring storm surges can provide a useful means of detecting trends in climate. Table 6.41 lists some notable storm surges recorded on the Queensland coast.

A wave recording program has been carried out by the Queensland Government for more than 30 years to better understand the threat of large waves brought about by severe climatic events. Figure 6.42 shows the locations of wave recording stations and wave height trends. While the plot shows the variability of the trends in average annual wave heights at each site, it is interesting to note that the sites where buoys are deployed in water depths of 20 metres or more experienced trends of increasing average wave heights over the monitoring period, while those in less than 20 metres of water experienced decreasing trends. As waves travel into shallow water, they begin to be affected by the seabed.

The largest wave recorded in Queensland was observed at the Brisbane wave station. It measured 13.1 metres and occurred during the passage of tropical cyclone Roger off the Queensland coast in March 1993. The wave occurred well off the coast in 80 metres of water.

Table 6.41 Notable storm surges recorded on the Queensland coast

Year	Place	Event	Estimated central pressure (hPa)	Surge height (m)
1884	Bowen		?	3.1
1887	Burketown		?	5.5
1896	Townsville	Sigma	?	›2.0
1899	Bathurst Bay	Mahina	914	14.0
1918	Mackay		935	3.7
1918	Innisfail		928	›3.0
1920	Cairns		988	›1.5
1923	Albert River	Douglas Mawson	974	›3.0
1934	Port Douglas		968	›1.8
1948	Bentinck Island		996	›3.7
1964	Edward River	Dora	974	5.0 ?
1971	Inkerman Station	Fiona	960	›4.0
1971	Townsville	Althea	952	2.9
1971	Edward River	Fiona	960	3.0
1972	Fraser Island	Daisy	959	3.0?
1976	Burketown	Ted	950	4.6 ?
1978	Weipa	Peter	980	1.2
1987	Karumba	Jason	970	2.0
1989	Ayr	Aivu	935	3.2
1995	Karumba	Warren	980	1.5
1996	Gilbert River	Barry	950	›4.0 ?
1996	Weipa	Ethel	980	1.2
1999	Mossman	Rona	970	1.4
2000	Cairns	Steve	977	1.0
2001	Karumba	Abigail	975	1.4
2002	Karumba	Bernie	985	1.3

Source: EPA



Coastal erosion (Photo: EPA)

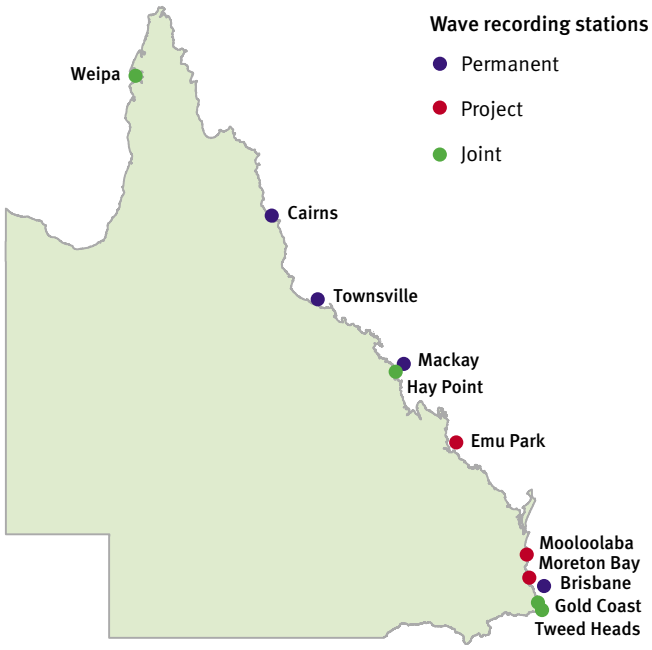


Figure 6.42 *Location of wave recording stations*
Source: EPA

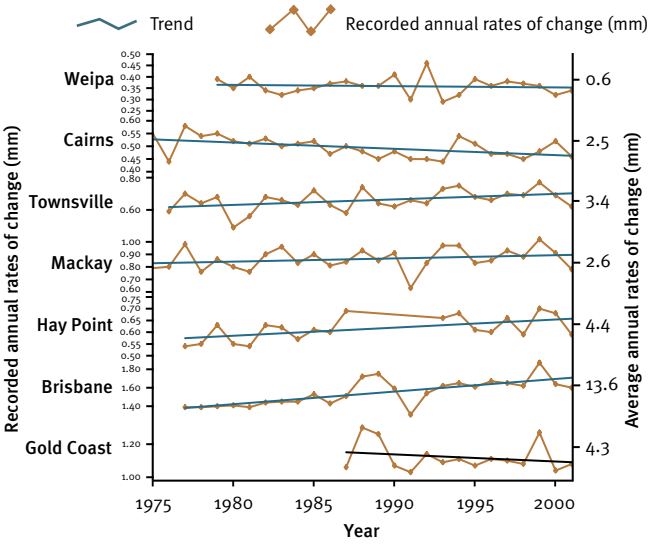


Figure 6.43 *Wave height trends from selected sites.*
Source: EPA

Average temperatures, particularly night-time minimum temperatures, have increased significantly over the past century (Lough 1997; see also Chapter 3, 'Atmosphere'). The full implications for human systems and natural ecosystems of such changes are the subject of ongoing research.

Data on the extent of coastal development in natural coastal buffer zones are scarce, but population data indicate that growing numbers of people are moving into the coastal zone and increasing the demands for coastal development. Table 6.42 gives an indication of the numbers of approvals for development in erosion prone areas declared by the EPA under the *Beach Protection Act 1968* by year and type. The EPA has declared erosion prone areas to provide a buffer between land uses and the coastline. From October 2003, the Beach Protection Act was repealed. The approvals shown in tables 6.42 and 6.43 are now administered through the Coastal Act.

Table 6.42 Numbers of development approvals in coastal erosion prone areas by year and type

Approval type	1999–2000	2000–01	2001–02
41B[a]	24	12	4
45[b]	18	22	21
47(1A)[c]	96	73	63

[a] Section 41B requires the local government to obtain the views of the Beach Protection Authority in relation to a proposed town planning scheme or amendments to an existing scheme where land affected by the scheme is in an erosion prone area.

[b] Section 45 requires the Governor in Council to give consent to any subdivision of land which is wholly or partially within the erosion prone area. In giving consent, the Governor in Council may give it subject to conditions which may include a condition requiring the surrender to the state of all or any land in the erosion prone area.

[c] Section 47(1A) requires the permission of the Beach Protection Authority to interfere with any sand etc. on state land in an erosion prone area. The permission is given to the trustee of the land and the trustee is normally the local government.

Source: EPA

The extent of land surrender, which preserves land for beach protection and coastal management purposes, and the number of applications received for building in vulnerable coastal areas give further indications of the trends in coastal development. Table 6.43 sets out the amount of surrendered land associated with subdivision applications between 1999 and 2002. Table 6.44 shows the status of applications received for development seaward of a coastal building line.

Table 6.43 Extent of surrendered land gazetted as a reserve for beach protection and coastal management purposes resulting from subdivision applications approved under section 45 of the *Beach Protection Act 1968*

Year	Length (m)	Area (m²)
1999	9 194	2 157 965
2000	583.6	24 684
2001	3 808	1 710 225
2002	7 339.1	174 435
Total	**20 924.7**	**4 067 309**

Source: EPA

Table 6.44 Numbers of applications for development seaward of a coastal building line, 1999–2002

Year	Approved	Refused	Pending
1999–2000	–	–	–
2000–01	–	–	–
2001–02	–	1	1

Source: EPA

Before 1995, individual local authorities had the discretionary ability to permit development seaward of a setback (or coastal building line). Some local authorities have continued to exercise this power without the involvement of the Beach Protection Authority.

Summary of condition and trend indicators

Coastal variability — physical processes

Indicator	CY	NG	SG	DC	SW	WT	BDT	MK	F	BM	SE	MD	DU
Sea level rise (mm)	3	2	4	–	–	2.5		3	3	2	1.5	–	–
Max. storm surge height (m)	14.0?	1.2	5.5	–	–	3.0		3.7	2.2	3.6?	1.8	–	–
Max. wave height* (m) and cause of event	5.8 Ethel	3.8 ??	–	–	–	7.1 Rona	5.5 Justin	7.1 Justin	7.2 David	8.9 Simon	13.1 Roger	–	–
No. of tropical cyclones (1910–2002)	66	67	43	22	3	42	43	23	36	22	10	6	18

*Wave height information refers only to the highest single wave event recorded at an operating wave station. This must be treated with caution, as no information is available from coastal centres where wave stations did not exist.

Key to NRM regions: CY = Cape York, NG = Northern Gulf, SG = Southern Gulf, DC = Desert Channels, SW = South West, WT = Wet Tropics, BDT = Burdekin Dry Tropics, MK = Mackay–Whitsunday, F = Fitzroy, BM = Burnett–Mary, SE = South East, MD = Murray–Darling, DU = Desert Uplands



Coastal modelling is being used to assess the long-term erosion at Holloways Beach, Cairns. Beach nourishment, groynes and an upgraded seawall design were considered as part of coastal modelling, to mitigate long-term erosion. Left: Holloways Beach 1979. Right: Holloways Beach 1999 (Photos: EPA)

Responses

Management of shoreline erosion in certain areas where development has already occurred is a continuing issue for state and local governments. Erosion management methods, such as the construction of seawalls and groynes and artificial beach nourishment, can be used to reduce the impacts of coastal hazards on land. However, seawalls and groynes can be expensive and can have undesirable effects on adjacent beaches. Artificial nourishment of an eroding beach is less likely to have negative impacts on nearby areas, although maintenance of an artificial beach may require regular and expensive replenishment of sand (EPA 2001). Table 6.45 provides information on beach nourishment projects between 1999 and 2002.

Table 6.45 Details of projects* approved by the Beach Protection Authority, 1999–2002

Year	Location	Quantity (m³)
1999–2000	Cardwell Beach, Cardwell Shire	1 000
	Pumicestone Passage, Caboolture Shire	500
	Rowes Bay, Townsville City	4 000
	Noosa Main Beach, Noosa Shire	230 000
2000–01	Baffle Creek, Miriam Vale Shire	200
	Wellington Point, Redland Shire	200
	Holloways Beach, Cairns City	60 000
	The Strand, Townsville City	55 000
	Urangan Beach, Hervey Bay City Council	35 000
	Noosa Main Beach, Noosa Shire	45 000
	Woorim Beach, Caboolture Shire	60 000
	Rowes Bay, Townsville City	4000
2001–02	Noosa Main Beach, Noosa Shire	140 000
	Baffle Creek, Miriam Vale Shire	200
	Noosa Main Beach, Noosa Shire	45 000
	Burnett Heads (north), Burnett Shire	40 000
	Airlie and Cannonvale beaches, Whitsunday Shire	1 000
	Victoria Point, Redland Shire	200
	Cairns Esplanade, Cairns City	5 000
	Maroochydore Beach, Maroochy Shire	100 000
	Rowes Bay, Townsville City	4000

*Some of these projects may have approval but may not yet have been undertaken. Some of the projects are for annual nourishment; only the expected nourishment for the year is given.

Source: EPA

The State Coastal Plan provides policy direction on adaptation to climate change, erosion prone areas, shoreline erosion management, coastal hazards and offshore structures. Erosion prone areas are to remain free of development; where development has occurred, future development should not be at an intensity greater than the existing development level.



Geotextile bags are filled with sand to construct a groyne at Maroochydore Beach. (Photo: EPA)

Regional coastal management plans will identify any priority areas for erosion management. When deciding on new urban development areas on the coast, an evaluation is to be carried out to identify the level of potential risk to life and property from coastal hazards. Construction of offshore structures in coastal waters will be approved only if there is a demonstrated need for them in the public interest, if significant adverse impacts on the longshore transport of sediments are prevented, and if there would be no increase in coastal hazards for the neighbouring foreshores (EPA 2001). Table 6.46 lists approved structures on the coast in the period 1999–2002.

An understanding of beach behaviour is necessary to arrive at appropriate solutions to the problems of erosion and coastal hazards. The EPA carries out investigations into coastal processes through data collection and studies that provide information on aspects such as the physical nature of the study area, beach profile variations, current and wave measurements, sediment sampling and water level variations. Detailed assessments of coastal management issues have been completed for:

- Holloways Beach, Cairns City;
- western foreshore, Bribie Island, Caboolture Shire; and
- McEwens Beach, Mackay City.

Table 6.46 Approved structures on the Queensland coast, 1999–2002

Year	Location	Type
1999–2000	Martins Creek, Toogoom, Hervey Bay City	Retaining wall
	Scarborough, Redcliffe City	Seawall extension
	Golden Beach, Caloundra City	8 geotextile groynes
	Hull Heads, Cardwell Shire	Rock revetment
	Tweed River entrance, Gold Coast City	Sand bypassing system
	Cairns Esplanade, Cairns City	Reclamation
2000–01	Flying Fish Point, Johnstone Shire	Rock seawall
	Southern entrance of Maroochy River, Maroochy Shire	Geotextile revetment
2001–02	Keppel Sands, Livingstone Shire	Groyne extension
	Molongle Creek, Bowen Shire	Bund wall
	Maroochydore Beach, Maroochy Shire	Geotextile groyne
	Happy Valley, Caloundra City	Rock seawall
	Thursday Island, Torres Shire	Rock revetment
	Rowes Bay, Townsville City	Retaining wall
	Airlie Beach, Whitsunday Shire	Revetment wall
	Noosa Main Beach, Noosa Shire	Artificial reef
	Margate Beach, Redcliffe City	Geotextile revetment
	Roundhill Creek, Miriam Vale Shire	Revetment wall
	Cardwell, Cardwell Shire	Retaining wall

Source: EPA

Case study: Environmental restoration of the southern Gold Coast beaches

The Tweed River Entrance Sand Bypassing Project (TRESBP) is an example of a beach nourishment and dredging operation that has restored condition to popular beaches on the southern Gold Coast (figure 6.43).

The natural process of sand transport along the coast near the Queensland-New South Wales border was severely disrupted after training walls were constructed at the Tweed River entrance in the 1960s. The walls trapped sand along Letitia Spit and starved beaches on the southern Gold Coast of their natural supply of sand. They also hindered safe passage into the Tweed River by contributing to the periodic formation of sand shoals at the river entrance. In 1989, it was estimated that over seven million cubic metres of sand had been trapped by the Tweed River training walls, and an equivalent volume had been eroded from the southern Gold Coast beaches.

A number of protection works were undertaken to safeguard foreshore development and restore beach amenity. These included rock revetments, groynes and beach nourishment campaigns. These protection works were only temporarily effective, as the cause of the erosion problems was reduced sand supply.

In 1994, the TRESBP was formally instigated after discussions between the Queensland and New South Wales governments. The project was implemented in two stages. Stage 1 involved dredging of the river entrance and offshore sources, and renourishment of the southern Gold Coast beaches with 3.6 million cubic metres of sand. Stage 2 involved the installation of a permanent sand bypassing system to deliver sand to the southern Gold Coast beaches from Letitia Spit in perpetuity.

The permanent bypassing system was commissioned in May 2001 and has met the project's objectives to:

- achieve a continuing supply of sand to the southern Gold Coast beaches at a rate consistent with the natural littoral drift rates updrift and downdrift, together with the supply of such additional sand to the beaches as is required to restore and maintain their recreational amenity; and
- establish and maintain a navigable depth of water of at least 3.5 m below Indian Springs Low Water in the approach to the Tweed River and within the entrance channel over a width equal to the distance between the rubble mound breakwaters.

In stage 2 of the project, extending to 5 November 2002, 2.33 million cubic metres of sand was delivered to the southern Gold Coast beaches by pumping and supplementary dredging. This sand delivery and the earlier dredging works have restored the southern Gold Coast beaches to their 1960s condition. Monitoring is continuing to ensure that the sand placement strategies match natural annual sediment transport rates and maintain beach amenity.

One aim of the monitoring process is to ensure that the surfing breaks of the southern Gold Coast are not detrimentally affected. Monitoring to date has shown that surfing conditions have been maintained and, in some cases, improved as a result of the project.

Figure 6.44 shows the prevailing wave climate, the calculated sediment transport due to the wave climate and the sediment quantities that have been placed on the southern Gold Coast beaches since 1995. Monitoring shows that low wave energy conditions have dominated since commissioning of the project; these have led to significant accretion of the southern Gold Coast beaches, which have returned to their former condition. Aerial photographs taken in 1946, 1982 and 2002 show the changes.

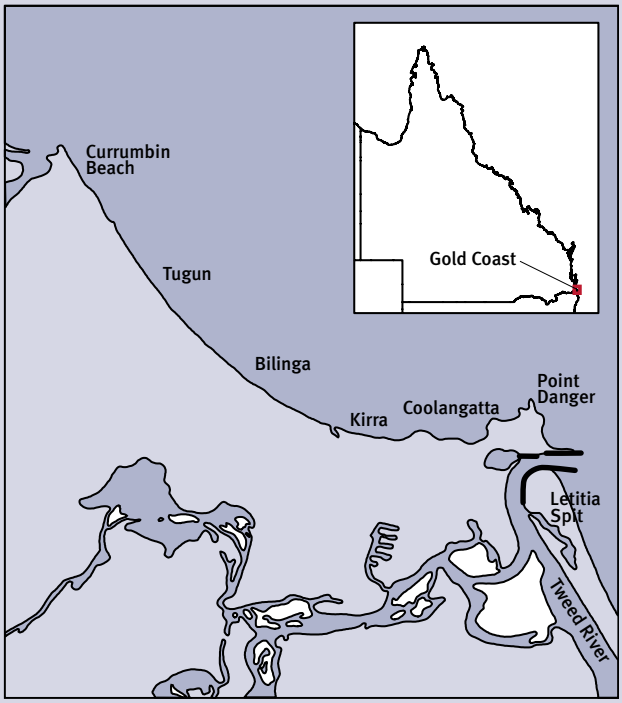


Figure 6.43 *Location of southern Gold Coast beaches*

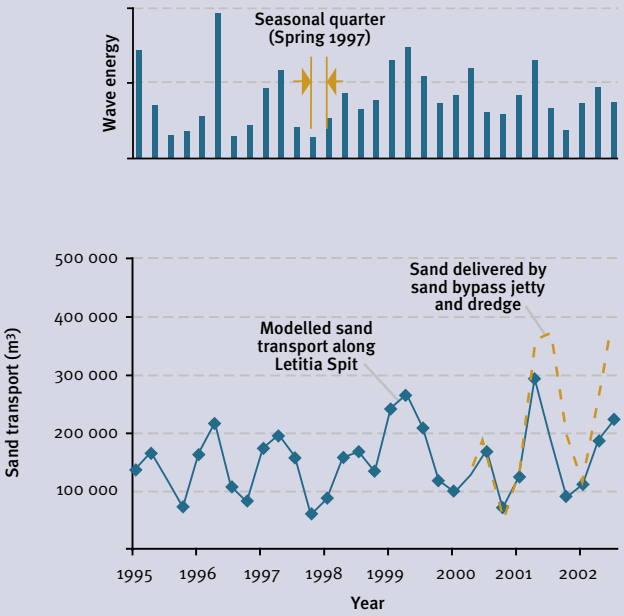


Figure 6.44 *Longshore sediment transport trends and the volume of material delivered to the southern Gold Coast beaches, 1995–2002*
Source: EPA



Changes to the southern Gold Coast beaches 1946–2002: photo taken in 1946 shows the pre-training wall entrance and waves breaking on the southern Gold Coast. (Photo: EPA and DNRM)



Photo taken in 1982 shows part of the southern Gold Coast beaches in an eroded state 20 years after the training walls were installed. (Photo: EPA and DNRM)



Photo taken in 2002 shows the bypassing system in place and part of the accreted southern Gold Coast beaches. (Photo: EPA and DNRM)

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Kewarra Beach looking north, Kewarra (Photo: Tourism Queensland)

7 Biodiversity

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Authors

David Francis, David McFarland, Sue McIntyre, Jeremy Thompson, Kristen Williams and Peter Young, Environmental Protection Agency; and Maria Van der Gragt, World Wide Fund for Nature

Reviewer

Colin Creighton, former CEO of National Land and Water Resources Audit

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Introduction

The report *State of the Environment Queensland 1999* (EPA 1999) established a baseline for reporting on the condition and trend of biodiversity in this state. Queensland contains some of the most species-rich parts of the Australian continent, and human impacts during the past 200 years have resulted in losses and declines in biodiversity. The increasing level of awareness of biodiversity conservation is reflected in major policy documents such as the National Strategy for the Conservation of Australia's Biological Diversity (Commonwealth of Australia 1996). However, little is known about taxonomic groups such as fungi and marine invertebrates.

The major pressures on biodiversity in Queensland were documented in 1999. They include the loss and fragmentation of native habitat, alteration and degradation of native habitat, and introduced plant and animal species. The *Vegetation Management Act 1999* now regulates broadscale clearing on freehold lands in the state, as well as establishing a policy for vegetation management that specifically takes into account the maintenance of biodiversity. Clearing on leasehold tenures that comprise around 65% of Queensland is regulated through the *Land Act 1994*. In the lead-up to the introduction of the new legislation, clearing rates were especially high.

To deal with some of the other pressures on biodiversity in a strategic and concerted manner, the Review of the National Strategy for the Conservation of Australia's Biological Diversity (ANZECC 2001) recommends the integration of biodiversity conservation with other facets of natural resource management. For the first time, the Environmental Protection Agency (EPA) has prepared a draft biodiversity policy framework for Queensland (EPA 2003). It will provide the platform for a comprehensive statewide biodiversity strategy and complement regional initiatives such as the draft South East Queensland Regional Nature Conservation Strategy. Other tangible signs of progress towards more integrated approaches to maintaining biodiversity in the landscape include the incorporation of targets for biodiversity in regional planning (MDBMC 2001).

The proportion of the state in formal conservation reserves has risen to just over 4%. The reserve network samples 74% of the regional ecosystems recognised. While formal reserves have traditionally been viewed as the major means of conserving biodiversity, they are being complemented by rapidly growing interest in off-reserve conservation areas, including nature refuges and land for wildlife, and the acquisition of key areas of conservation interest by local government and non-government organisations.

The protection and maintenance of biodiversity are dependent to a large degree on the collection and provision of good-quality information. During the past three years there has been substantial development of WildNet, the EPA's statewide flora and fauna database, and the Queensland Herbarium's mapping of ecological communities now covers 85% of the state. In the same period, the EPA has prepared biodiversity planning assessments (after Chenoweth EPLA Ltd 2000) that are being used as a basis for providing information for bioregions in central and southern Queensland. At the local scale, research and data-collection projects continue to play a key role in improving the quality of information about biodiversity.



There is an ongoing need for scientific data on Queensland's wildlife. (Photo: EPA)

Habitat protection

Summary

The major pressures on Queensland's biodiversity induced by human settlement and land use continue to be the loss, degradation and fragmentation of native habitat. While the major part of Queensland has relatively continuous native vegetation cover (82% remnant native vegetation in 1999), more fertile landscapes in wetter parts of the state have been reduced to less than 30% of native vegetation cover, a widely accepted critical threshold for habitat retention. Clearing has also been expanding into semi-arid areas in recent years. The rate of clearing has risen during the past decade, although the introduction of the Vegetation Management Act appears to have reversed this trend.

The extent of other pressures on biodiversity, such as altered fire regimes and grazing pressure in remnant ecosystems, are not as readily reported upon as loss of habitat. The biodiversity status reveals declines in the condition of regional ecosystems in bioregions subject to little or no clearing.

About 4.1% of Queensland is contained within formal conservation reserves. Given its modest extent, the reserve network performs well for the criterion comprehensiveness, as measured using regional ecosystems, but poorly for adequacy, based upon a widely accepted target of 15% of the state. There are indications that off-reserve conservation initiatives in Queensland have gathered momentum since 1999.

Summary of condition and trend indicators

Vegetation

Terrestrial bioregions	Remnant native vegetation	Extent and condition of native vegetation
Northwest Highlands	–	▼
Gulf Plains	–	–
Cape York Peninsula	–	▼
Mitchell Grass Downs	▼	▼
Channel Country	–	–
Mulga Lands	▼	▼
Wet Tropics	▼	▼
Central Queensland Coast	▼	▼
Einasleigh Uplands	▼	▼
Desert Uplands	▼	▼
Brigalow Belt	▼	▼
Southeast Queensland	▼	▼
New England Tableland	▼	▼

Remnant native vegetation

- **Good** 70–100% of the bioregion with remnant vegetation
- **Moderate** 40–70% of the bioregion with remnant vegetation
- **Poor** 0–40% of the bioregion with remnant vegetation

Key to trend:

- ▼ Degrading
- ▲ Improving
- – No change
- ? Uncertain
- X Not assessed

Extent and condition of native vegetation

- **Good** 0–20% of regional ecosystems in the bioregion classified as endangered or of concern
- **Moderate** 20–50% of regional ecosystems in the bioregion classified as endangered or of concern
- **Poor** 50–100% of regional ecosystems in the bioregion classified as endangered or of concern
- **Not assessed**



Habitat loss, degradation and fragmentation are the major pressures on biodiversity, particularly in the more fertile landscapes. (Photo: Queensland Museum)

Pressures

Native vegetation clearing and modification

Loss of native vegetation affects biodiversity through the depletion and modification of habitat. Vegetation loss is taken here to include both the removal of woody species in natural ecosystems by clearing and the loss and modification of non-woody natural ecosystems, such as grasslands and shrublands.

Quantifying the extent to which all individual taxa have declined and may continue to decline due to clearing and modification of habitat is an unrealistic task because of the number of species present within Queensland. This type of assessment is reserved for taxa that are identified as being a priority for conservation (see 'Biodiversity in modified habitats—shades of grey', page 7.10). For other taxa, vegetation or regional ecosystems provide a surrogate for describing the pressure from clearing and modification because these data are available for most of the state.

The shorter-term impacts of clearing on plants and animals at any site range from the total loss of species that would be experienced in the conversion of native vegetation to cultivation, improved pasture or urban use to a reduction in species richness and diversity that would be experienced when woody vegetation is converted to native pasture. The cumulative and longer-term impacts of clearing also need to be taken into account. Clearing across the landscape isolates populations, reduces the size of populations, favours certain species over others and increases the opportunities for invasive and mobile taxa to displace native species (Boulter et al. 2000). For long-lived taxa such as birds, there is a time lag between loss of habitat and consequent loss of species, a process that has been referred to as 'extinction debt' (Possingham and Field in prep; Cogger et al. 2003).

The rate of clearing of woody vegetation in Queensland as measured by the Statewide Landcover and Trees Study (SLATS 2003) has varied over the past decade. It increased during the 1990s in the lead-up to the introduction of the Vegetation Management Act. There was a significant decline in the following year. The information provided by SLATS (2003) includes woody vegetation considered to be remnant as well as regrowth. Queensland Herbarium data (Wilson et al. 2002; Accad et al. 2001) provide a comparison of rates of loss of remnant vegetation for the period 1997–99 (table 7.1). The higher rate of loss of remnant vegetation indicated by Accad et al. (2001) is attributed to factors such as conversion of native grasslands to cultivation and clearing of very open vegetation such as savanna woodlands and sparse shrublands.



Land clearing rates peaked in 1999–2000, when 757 000 ha of vegetation were cleared. (Photo: DNRM)

Table 7.1 Loss of vegetation in Queensland 1991–2001, based on SLATS (2003)

	Interval				
	1991–95	1995–97	1997–99	1999–2000	2000–01
Hectares cleared per year	289 000	340 000	425 000 446 000*	757 000	377 000
Percentage of Queensland	0.17	0.20	0.26	0.46	0.23

*Comparative data for remnant vegetation sourced from Queensland Herbarium—see text for details.

Source: SLATS 2003

Table 7.2 shows the extent of clearing across the state's bioregions in 1997–99, based on Queensland Herbarium data. The bioregions with the greatest loss in terms of total area cleared in this period were the Brigalow Belt, Mulga Lands and Desert Uplands. They also experienced the highest loss in terms of the proportion of the bioregion that was cleared.

The Central Queensland Coast, Southeast Queensland and New England Tableland bioregions, which had lost a substantial proportion of vegetation before 1997, continued to lose vegetation as a result of clearing. The lowest rates of clearing have occurred in bioregions in the state's west, north-west and far north, the exception being the Mitchell Grass Downs, where gidgee is being selectively cleared (EPA 2002a).

Comparison between the periods 1991–95, reported on in 1999, and 1997–99, the most recent interval for which data are available, indicates that clearing rates increased in several bioregions, most notably the Mitchell Grass Downs, Mulga Lands, Desert Uplands and Brigalow Belt. There was, however, a decrease in the Southeast Queensland and Central Queensland Coast bioregions.

Clearing has had different impacts on landscapes and vegetation types across the state. Major geographic and historical patterns in clearing in Queensland have been widely documented—for example, the clearing of rainforest for agriculture on the Atherton Tableland (Frawley 1983) and the extensive clearing of brigalow country for grazing and cropping after World War II (Bailey 1982). Several bioregions in eastern Queensland have subregions in which the area of remnant native vegetation has fallen below or is approaching 30% (figure 7.1). Thirty percent habitat retention has been proposed as a critical threshold for maintaining species populations in the landscape (Andren 1994).

Table 7.2 Clearing of remnant vegetation in Queensland's terrestial bioregions

Bioregion	Percentage of bioregion remnant	Area cleared (ha/year) 1997–99 (and percentage of region)	Area cleared (ha/year) 1991–95 (and percentage of region)
Northwest Highlands	99.0	3 800 (0.04)	30 (0.0)
Gulf Plains	100.0	2 100 (0.01)	1 200 (0.01)
Cape York Peninsula	98.6	0 (0.0)	1 000 (0.01)
Mitchell Grass Downs	94.8	27 000 (0.11)	18 000 (0.07)
Channel Country	99.8	500 (<0.01)	160 (<0.01)
Mulga Lands	81.0	85 000 (0.46)	63 000 (0.34)
Wet Tropics	77.0	1 300 (0.07)	3 600 (0.18)
Central Queensland Coast	57.0	2 600 (0.18)	1 800 (0.13)
Einasleigh Uplands	98.0	2 800 (0.03)	2 000 (0.02)
Desert Uplands	87.4	51 100 (0.73)	36 000 (0.51)
Brigalow Belt	42.9	260 000 (0.71)	151 000 (0.41)
Southeast Queensland	43.1	7 400 (0.12)	9 700 (0.16)
New England Tableland	33.4	1 800 (0.23)	1 300 (0.17)
Queensland	**82.0**	**445 400**	**288 790**

Source: EPA



Figure 7.1 *Remnant vegetation in subregions in central and southern Queensland*

Table 7.3 presents data showing the loss from clearing for broad vegetation types. Until 1999, the broad vegetation types with the greatest loss in terms of their pre-clearing area were rainforests and vine thickets; subtropical woodlands such as poplar box, narrow-leaved and silver-leaved ironbark, mountain coolibah and cypress pine woodlands; and brigalow/gidgee. Historically, brigalow has experienced greater rates of clearing than gidgee, a species of semi-arid areas. However, the rate of clearing of gidgee has been increasing as clearing gradually moves into drier environments. During the period 1997–99 subtropical woodlands and brigalow and gidgee ecosystems continued to experience the highest rate of clearing in the state. The data indicate that 84% of the mapped wetland and riparian vegetation remains.



Heathland (Photo: L. Knight, EPA)



Subtropical woodland (Photo: EPA)



Tropical woodland (Photo: L. Knight, EPA)



Rainforest (Photo: L. Knight, EPA)

Table 7.3 Clearing across broad vegetation types in 1997–99

Clearing by broad vegetation type	Total pre-clearing area of type (ha)	Pre-clearing area as percentage of Queensland	Percentage of pre-clearing area remaining in 1999	Area cleared (ha/year) 1997–99 (and as percentage of total area of type)
Wet and dry sclerophyll forests	4 535 500	3	67	9 000 (0.2)
Rainforests/vine thickets	3 823 500	2	49	5 000 (0.13)
Subtropical woodlands	23 625 100	14	50	182 000 (0.77)
Brigalow/gidgee	18 789 600	11	48	86 000 (0.1)
Other acacia (except mulga)	9 591 600	6	97	13 000 (0.14)
Tropical woodlands	31 831 100	18	96	47 000 (0.15)
Native grasslands	34 927 900	20	96	23 000 (0.07)
Heath	1 533 200	1	94	2 000 (0.13)
Mulga/spinifex and arid woodlands	23 413 000	13	99	38 000 (0.16)
Wetlands and riparian vegetation with eucalypts	19 430 500	11	84	40 000 (0.21)
Mangrove	1 933 200	1	92	1 000 (0.05)
Total	**173 434 200**	**100**	**82**	**446 000**

Source: EPA

Table 7.4 Clearing (ha/year) across endangered, of concern and not of concern regional ecosystems in 1997–99

Bioregion	Endangered	Of concern	Not of concern	Total area
Northwest Highlands	na	na	na	3 800
Gulf Plains	na	na	na	2 100
Cape York Peninsula	0	0	0	0
Mitchell Grass Downs	0	11 000	16 000	27 000
Channel Country	0	100	400	500
Mulga Lands	7 400	45 000	33 000	85 400
Wet Tropics	300	400	600	1 300
Central Queensland Coast	600	700	1 300	2 600
Einasleigh Uplands	na	na	na	2 800
Desert Uplands	400	9 900	41 000	51 300
Brigalow Belt	55 000	99 000	106 000	260 000
Southeast Queensland	800	2 300	4 300	7 400
New England Tableland	100	1 500	200	1 800
Total				**446 000**

na = not available

Source: EPA

Table 7.4 shows the extent of clearing in relation to the biodiversity status of regional ecosystems in bioregions where regional ecosystem mapping has been completed or is in progress (Wilson et al. 2002).

In bioregions where regional ecosystem mapping has been completed, 54% of the clearing in the period 1997–99 occurred in endangered and of concern regional ecosystems. Endangered and of concern regional ecosystems contain particular combinations of plant and animal species associated with distinctive geology, landform, soils and climate features, and these combinations are at risk of disappearing from the landscape if clearing continues. Some taxa, especially animals and plants with restricted distributions, are at risk of extinction if clearing continues.

Case study: Using land resource information in land use planning

The Desert Uplands bioregion (figure 7.2) is characterised by sandy, low-fertility soils and a variable, semi-arid climate. Most of the bioregion remains in a relatively natural condition and its biodiversity is largely intact (Morgan et al. 2002). Cattle grazing, dependent largely on native pastures, is the major industry.

Some clearing for introduced pasture, especially buffel grass, has been occurring (table 7.2). However, much of the region is assessed as having regional ecosystems of low suitability for more intensive pasture development, based on a widely applied land capability classification. For these areas, Morgan et al. (2002) recommend that clearing be kept to a minimum, the major focus being on maintaining the health of the native pastures.

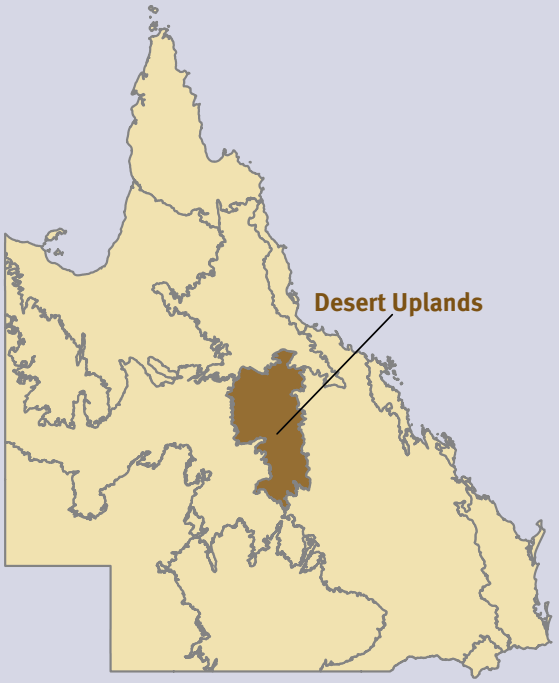


Figure 7.2 *Location of the Desert Uplands*

Fire regimes

Australian ecosystems have evolved with fire. Many plant and animal species and communities are dependent on fire, while others, such as rainforest, require fire exclusion. The optimal fire regime (season, frequency, intensity and extent) varies from ecosystem to ecosystem. In the modern Australian context, many natural areas will not retain their biodiversity without active fire management.



Tree ferns growing at the ecotone between regularly burnt woodland and unburnt rainforest (Photo: L. Knight, EPA)

Information is needed about natural fire regimes compared with the current ones, and the responses of species and vegetation communities to both types. For most vegetation types, little is known about current fire regimes, and even less about pre-European ones.

Pre-European fire patterns—the benchmark for determining fire regimes

In northern Australia, pre-European fire regimes have been inferred from anecdotal accounts, historical observations and ethnographic records (Russell-Smith 2002; Chase and Sutton 1981; Hill et al. 1999; Crowley and Garnett 2000). While the data are sparse and geographically biased towards coastal and subcoastal regions, they consistently show that burning was undertaken throughout the dry season with curing of grassy fuels, particularly in the early to mid-season under cooler, milder conditions (Russell-Smith 2002; Fensham 1997).

In the Southeast Queensland bioregion, a research-based approach was used to infer pre-European fire regimes through the Fire and Biodiversity Consortium. Following a review of the fire research literature by Tran and Wild (2000), Watson (2001) suggested ecological fire regimes for broad vegetation types; these varied from no fire in rainforest to fire-free intervals of three to six years in grassy understorey dry sclerophyll forests and woodlands (table 7.5). Guidelines for fire management were developed to help small landholders and local government implement fire regimes and practices that support conservation of biodiversity (Tran 2002a, 2000b; Tran and Peacock 2002). These fire regime guidelines may be applicable to vegetation of similar type throughout Queensland.

Table 7.5 Suggested fire intervals for vegetation types in Southeast Queensland

Vegetation type	Fire intervals in years
Rainforest	Fire exclusion
Wet sclerophyll forest	20–100+
Grassy dry sclerophyll forest and woodlands	3–6
Shrubby dry sclerophyll forest and woodlands	7–25
Coastal heathlands	7–20
Inland (rocky) heathlands	15–50
Paperbark (*Melaleuca quinquenervia*) woodlands	15–30

Source: After Tran 2001, adapted from Watson 2001

Monitoring fire patterns—an input to understanding management opportunities

Current information on fire extent and season in north Queensland has been derived from satellite remote sensing and fire incident data. Figure 7.3 summarises the Queensland results from a pilot study by Craig et al. (2002) of fire patterns across Australia between April 1998 and March 2000. Daylight passes of the NOAA satellite pick up fire 'scars' greater than 4 km² and for the two years of the pilot study showed large-scale burning occurring annually across northern Australia. In north Queensland, more than 30% of the extent of three bioregions—Northwest Highlands, Cape York Peninsula and Gulf Plains—was burnt. The Cape York Peninsula Sustainable Fire Management Project is using information from satellites to compile a fire history for the past five years and monitor real-time fire activity from 2001 onwards. Figure 7.4 shows the pattern of fire-affected areas (fire scars) on Cape York Peninsula from May to October 2000. Linking the fire regime changes to biodiversity condition is the next challenge as this work progresses.



Grassy woodlands and open forests recover quickly from fire. (Photo: L. Knight, EPA)

Valuable information about the current location and extent of fires exists in fire incident databases held by land management agencies and emergency services:

- the Queensland Fire and Rescue Authority, since 1999, has compiled fire permit information from volunteer fire wardens and brigades. Although the quality of reporting varies, the database is a valuable resource for assessing seasonal fire activity around the State (QFRA 2002);
- the Department of Main Roads has implemented district-based fire threat management programs that include provision for burning-off activities within transport corridors, with GIS-based records of vegetation type, fuel loads, wildfire incidence, previous treatments, area treated per year and seasonal weather patterns (DMR 1998);
- the Queensland Parks and Wildlife Service manages fire on and near state forest and protected areas for ecological purposes (QPWS 2001). Fire management plans are prepared for individual protected areas, with GIS-based recording of fire events (QPWS 2002). During 2001, more than 841 000 ha of burn area was recorded (Clarkson, R., pers. comm. June 2002);
- Department of Primary Industries—Forestry manages fire hazard reduction and wildfire suppression in state forests. Operational fire statistics are published in its annual reports. In 2000–01, more than 160 000 ha was burnt; wildfires in native forest accounted for nearly 25 000 ha, and prescribed burns in native forest for over 130 000 ha (DPI Forestry 2001);
- the Department of Natural Resources and Mines is researching and testing satellite fire monitoring methods to extract daily 'hotspots' information (1.1 × 1.1 km pixels) from imagery. Coordinates of hotspots within specified areas of interest are forwarded to fire management authorities and private landholders. A database of current and past fires is available on a public website and supports operations such as the Cape York Peninsula Sustainable Fire Management Project: ‹www.nrm.qld.gov.au›.

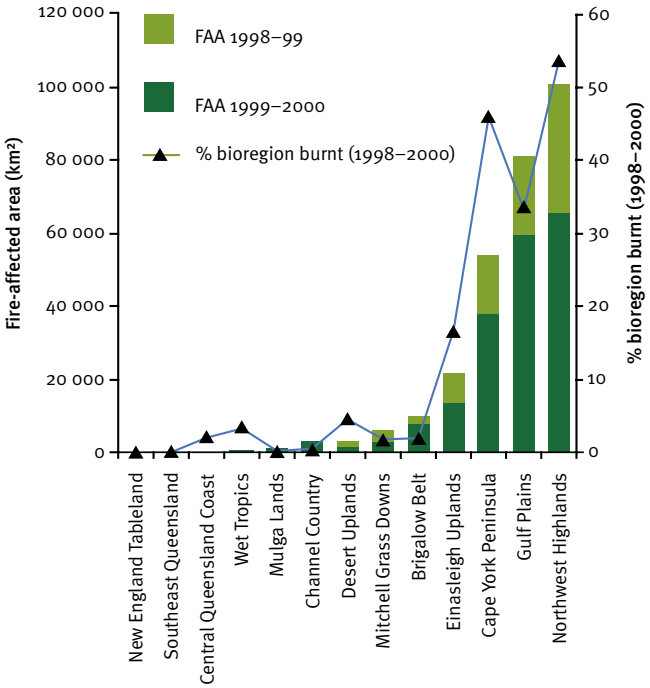


Figure 7.3 *Cumulative annual extent of fire-affected areas (FAAs) in each of Queensland's terrestrial bioregions between April 1998 and March 2000*
Source: Craig et al. 2002

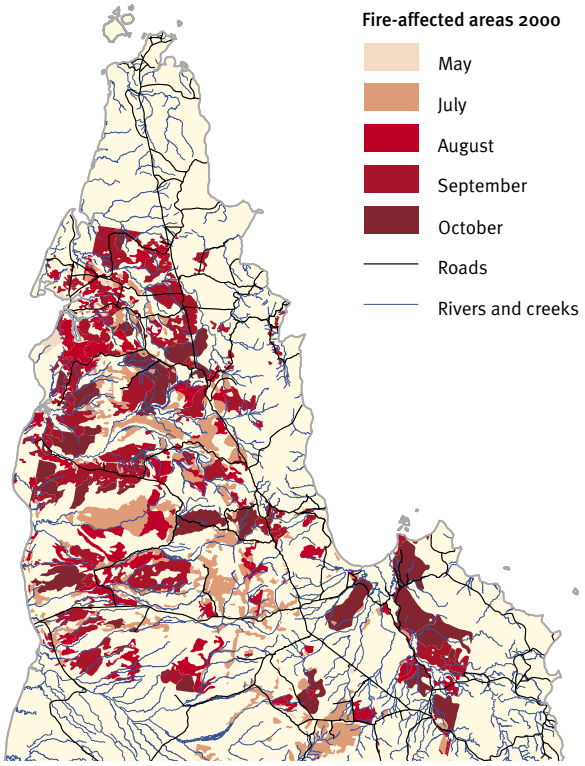


Figure 7.4 *Identified fire-affected areas (May to October 2000), Cape York Peninsula*
Source: Peter Thompson, CYP Development Association Inc., <www.cypda.com.au>

- the Sentinel Fire Mapping website, ‹www.sentinel.csiro.au›, is an Internet-based mapping tool designed to provide timely fire location data to emergency service managers across Australia. It results from collaboration between the Defence Imagery and Geospatial Organisation, CSIRO Land and Water and Australian Geosciences. The mapping system allows users to identify fire locations that pose a potential risk to communities and property.

Figure 7.4, showing fire-affected areas on Cape York Peninsula, demonstrates the feasibility of integrating field incident reports with satellite imagery in the management of fire regimes for the protection of both property and biodiversity. A consistent and coordinated approach to the collection of fire information by state agencies would facilitate the development of strategic fire management practices that are sympathetic to the needs of both property owners and biodiversity. The guidelines developed for Southeast Queensland vegetation types (table 7.5) are an example of the benchmark information required to support fire management in each bioregion.

Monitoring the impact of fire on biodiversity

The majority of wildlife and ecosystem research projects undertaken through the Queensland Parks and Wildlife Service include fire and fire monitoring as a key objective (Bailey et al. 2000). Many of these projects are in the early stages or monitoring is in progress, so that little information is available to assess and develop fire management recommendations at this stage. As findings come to hand, they are used as input for fire management plans (QPWS 2001) and codes of practice (EPA 2002b).

Case study: Fire—a key tool in developing tree hollows

Ensby et al. (2000) prepared a review of the effects of grazing and associated fire on biodiversity to inform and guide resource management and research in Queensland. Fires associated with 'green pick' for cattle, wildfires and prescribed fuel-reduction burns destroy some hollow-bearing trees and impede recruitment from regrowth (Cowley 1971; Woinarski and Recher 1997). Fires also create new hollows and hollow trees (Inions et al. 1989; Lindenmayer et al. 1990).

In parts of south-east Queensland, a historical legacy of large tree harvesting combined with treatment (poisoning and ringbarking) of poor-form trees has meant that approximately 50% of hollow trees are standing stags (Ross 1999). The habitat value of these stags to hollow-dependent fauna lasts as long as their standing life, which is much shorter than that of a living hollow-bearing tree. Climatic conditions, which affect rates of wood decay, and the frequency and intensity of fire influence stag longevity (Borsboom 1991; Banks 1993).

The preservation of standing stags and the recruitment of live hollow trees are key conservation management objectives in the forests of south-east Queensland. The photograph shows the mixed effect of a cool prescription burn on the hollow of a living tree. Each successive fire alters the nature of the hollow and its potential suitability for particular hollow-dwelling fauna. Codes of Practice for Native Forest Timber Production(EPA 2002b) include guidelines to minimise fire damage to habitat.



Fires can both create and destroy tree cavities that are used by hollow-dependent fauna, such as owlet nightjars. (Photo: L. Knight, EPA)

Condition and trend

Extent and condition of native vegetation

In the first part of this chapter, regional ecosystems and vegetation have been used to define the extent to which clearing and habitat modification are affecting biodiversity because of the limited information available for individual species, particularly those that are common. Regional ecosystems and vegetation are also the most readily available source of information for assessing the present extent and condition of biodiversity. The biodiversity status of regional ecosystems (EPA 2002a; Sattler and Williams 1999) is used to provide an indicator of condition.

Eighty-two percent of Queensland has been mapped by the Queensland Herbarium as remnant native vegetation (Wilson et al. 2002) (table 7.6). Clearing of vegetation has been much more widespread across the east and south of the state, where three bioregions—Brigalow Belt, Southeast Queensland and New England Tableland—have lost over 50% of their native vegetation. Some areas within the Wet Tropics, Mulga Lands and Central Queensland Coast bioregions have also been extensively cleared.

Subregions defined within each bioregion provide a finer scale of resolution for analysing landscape distribution and the environmental impacts of past and present land uses (Morgan 2001). Figure 7.1 shows the subregions in central and southern Queensland where remnant vegetation has fallen below 30%, a figure that is widely used as a minimum threshold for habitat retention. In contrast to these areas, western, north-western and far northern parts of the state have experienced negligible levels of clearing.

Table 7.6 Proportion of each bioregion that is remnant vegetation and proportion of regional ecosystems categorised as endangered, of concern and not of concern

Bioregion	Percentage of bioregion remnant	Percentage of regional ecosystems endangered	Percentage of regional ecosystems of concern	Percentage of regional ecosystems not of concern
Northwest Highlands	99	7	44	49
Gulf Plains	100	3	38	59
Cape York Peninsula	98.6	3	42	55
Mitchell Grass Downs	94.8	2	17	81
Channel Country	99.8	4	5	91
Mulga Lands	81	7	24	69
Wet Tropics	77	23	27	50
Central Queensland Coast	57	23	58	19
Einasleigh Uplands	98	2	50	48
Desert Uplands	87.4	21	36	43
Brigalow Belt	42.9	22	36	42
Southeast Queensland	43.1	15	47	38
New England Tableland	33.4	52	32	16

Depletion of regional ecosystems due to clearing and modification is the primary contributor to the high proportion of endangered and of concern regional ecosystems in the New England Tableland, Southeast Queensland and Brigalow Belt, and parts of the Wet Tropics, Mulga Lands and Central Queensland Coast bioregions. In other areas, the decline in condition of regional ecosystems has been the primary cause of their of concern status. Their condition has declined because of weeds, modification to floristic and structural composition due to trampling and grazing by domestic and feral animals, scalding and topsoil loss due to total grazing pressure, and changes in hydrology arising from bunding, dams and groundwater extraction.



Land clearing in the Desert Uplands (left) and South-west Queensland (right). (Photos: EPA)

Case study: Biodiversity in modified habitats—shades of grey

The concept of habitat clearing causing the total and permanent loss of biodiversity often dominates our thinking. In reality, it is the spatial patterns of clearing and the intensity of land use following clearing that determine the fate of habitats and species through time.

In a study area located in subtropical woodlands north of Toowoomba, in the Southeast Queensland bioregion, most of the plant species diversity is contained within the ground stratum. Over 400 species of grasses and herbs have been recorded (McIntyre and Martin 2002). The most intact habitats survive along roadsides and stock routes, where tree clearing and grazing are limited. The diverse ground layer is dominated by grazing-sensitive grasses such as native sorghum and kangaroo grass. In areas that are cleared and grazed many native species persist, including some of the original tree species that remain as lignotubers or as scattered trees or clumps.

At the other extreme are areas converted to sown pastures or cultivation. The number of native species in sown pastures is substantially reduced. Exotic species are dominant, but some native taxa such as Queensland bluegrass and *Bothriochloa* spp. persist. Cultivation has the greatest impact as it destroys much of the potential for tree and shrub regeneration, and in this sense, the woodland habitat is effectively lost when cultivation occurs.

The key to maintaining native plant diversity in the study area is to limit intensification of land use and maintain a range of grazing regimes. The study also indicates that monitoring only tree cover does not give a comprehensive picture of the extent to which elements of biodiversity are retained in the landscape.



Land management practices can influence the extent to which native grasses survive sheep and cattle grazing pressures. (Photo: EPA)

Responses

Terrestrial protected areas

Formal reserves established under the *Nature Conservation Act 1992* and managed by the Queensland Parks and Wildlife Service account for most of the land in Queensland dedicated to nature conservation. Off-reserve conservation, through cooperative programs involving landholders and land acquisition by local government and private nature conservation organisations, is, however, growing in importance. These conservation areas complement the formal reserve system, although they may continue to serve functions other than biodiversity conservation.

In June 2002, a total area of 7 125 303 ha, or 4.1 % of Queensland, was contained in protected areas, up from 7 058 946 ha (3.89%) in 1999. The Nature Refuge and Land for Wildlife programs protected over 270 000 ha of wildlife habitat including 14 regional ecosystems not represented in national parks. The total area of nature refuges was 33 209 ha (compared with 12 099 ha in 1999), and a further 159 000 ha was awaiting gazettal. In coastal southern Queensland local governments have acquired over 16 000 ha of land that contributes to maintaining biodiversity. Private nature conservation bodies have also acquired several large properties in central Queensland during the past two years.

The Queensland Government is aiming to increase the percentage of the state in protected areas through major initiatives including the Southeast Queensland Forest Agreement and the Cape York Peninsula acquisition program. Currently, 733 100 ha of state forest in the Southeast Queensland and Wet Tropics bioregions is being converted to conservation tenure. This will increase the total area reserved in Queensland to 4.5% of the state.

Targets established in Australia to guide the development of reserve networks aim at inclusion of all regional ecosystems present in a bioregion and 15% of the pre-clearing area of each regional ecosystem (JANIS 1996). Since the 1970s the goal in Queensland has been to maximise the amount of biodiversity sampled within areas acquired as protected areas—for example, by ensuring that regional ecosystems that are unreserved or poorly conserved are contained within any prospective acquisitions. This has resulted in a steady increase in the number of regional ecosystems within protected areas in each bioregion.

Table 7.7 shows the extent of protected areas and the extent to which the regional ecosystems of each bioregion are represented. Comparison with data presented in 1999 indicates an increase in the number of regional ecosystems represented in reserves from 69% to 74%. However, comparisons for time intervals need to be qualified until regional ecosystem mapping has been completed for the whole of Queensland. The increase is due partly to incorporation of new areas into the reserve estate and partly to improved levels of information about regional ecosystems in bioregions such as the Brigalow Belt. In the Central Queensland Coast bioregion, the refinement of information has resulted in a decrease in the proportion of regional ecosystems in reserves. The refined Herbarium data also indicate that 4% of the regional ecosystems in reserves are represented by a very small area: less than a total area of 30 ha in reserves for a number of rare regional ecosystems and less than a total area of 100 ha in reserves for some common regional ecosystems, most of which have remnant areas of many thousands of hectares. Such a small area reserved may not constitute a viable habitat area for common regional ecosystems.

Regional ecosystems with a not of concern biodiversity status have a much higher level of representation in reserves than of concern and endangered regional ecosystems. This is a reflection of the distribution and abundance of regional ecosystems. Not of concern regional ecosystems are often widespread in the landscape and can be readily captured in the reserve network. In contrast, endangered and of concern regional ecosystems often occur in small, localised patches surrounded by cleared and modified country. In these situations, higher levels of protection may be achieved only through cooperation with landholders.

The proportion of bioregions in reserves ranges from 1.6% of the Mitchell Grass Downs to 13.3% of Cape York Peninsula and 19% of the Wet Tropics. The 15% target has been reached for 0–36% of regional ecosystems in bioregions with completed regional ecosystem mapping (table 7.7).



Albinia Downs National Park, near Emerald in central Queensland, was acquired in 1999 to protect the endangered King Blue Grass, which had been reduced to less than 1% of its original distribution. (Photo: EPA)

Table 7.7 Percentages of terrestrial bioregions in reserves, reservation status of regional ecosystems by biodiversity status (E = endangered, OC = of concern, NOC = not of concern) and percentages of regional ecosystems with >15% of pre-clearing extent reserved

Bioregion	Percentage of bioregion in reserves	Percentage of regional ecosystems reserved 1999	Percentage of regional ecosystems reserved	No. E regional ecosystems in bioregion and (no. in reserves)	No. OC regional ecosystems in bioregion and (no. in reserves)	No. NOC regional ecosystems in bioregion and (no. in reserves)	Percentage of regional ecosystems >15%
Northwest Highlands	3.7	66	66	3 (2)	18 (11)	20 (14)	–
Gulf Plains	2.5	30	30	2 (1)	32 (8)	49 (16)	–
Cape York Peninsula	13.3	84	84	6 (2)	88 (62)	117 (114)	36
Mitchell Grass Downs	1.6	43	43	1 (0)	10 (3)	43 (20)	0
Channel Country	6.7	79	79	2 (1)	3 (1)	51 (42)	14
Mulga Lands	2.5	73	71	5 (4)	20 (14)	41 (30)	–
Wet Tropics	19.0	77	68	24 (16)	27 (16)	54 (49)	–
Central Queensland Coast	10.0	81	89	17 (12)	37 (29)	15 (15)	–
Einasleigh Uplands	2.4	77	57	1 (0)	24 (17)	22 (19)	–
Desert Uplands	2.6	59	43	16 (4)	29 (14)	33 (28)	10
Brigalow Belt	2.2	80	67	38 (21)	59 (48)	71 (66)	14
Southeast Queensland	6.7	90	86	22 (15)	71 (63)	55 (55)	36
New England Tableland	3.5	72	67	14 (8)	7 (7)	4 (3)	32
Queensland	**4.1**	**74***	**69**	**151 (92)**	**425 (293)**	**575 (471)**	

* 4% of the regional ecosystems have a very small total area in reserves.

Case study: More than meets the eye

For much of the time native grasslands, especially when viewed from a distance, resemble dry and brown cleared paddocks. Their hidden complexity and values are discovered when they are observed closely over time.

Over the past ten years, the profile of remnant native grasslands on the Darling Downs has been raised following a survey and mapping project (Fensham 1998). The remnants, which are small and scattered such as the examples shaded light blue on the image below, grow on heavy basalt-derived soils. They are known to support over 250 plant species. Birds, insects and mammals use the grasslands for food, shelter and breeding. The grasslands also assist agricultural production in the surrounding area by facilitating pollination and supporting predators. Much of the natural regeneration of grassland species is from seed. Maintaining sources of seed is important if native species are to continue to compete with weeds and recover from disturbances such as slashing and maintenance of road verges.

A follow-up project undertaken by the World Wide Fund for Nature (Goodland 2000) has assessed the condition of remnants, recorded the presence of rare and threatened flora and collected data for a baseline fauna survey.



Remnant grassland (light blue) among intensive agriculture areas, Darling Downs (Image: EPA and LandSat)

While many of the remnants on the Darling Downs are under 10 ha, the project has shown that they:

- maintain populations of rare and threatened plants such as native thistle (*Stemmacantha australis*) and hairy anchor plant; and
- provide habitat for a broad range of animals. Some of the more significant sightings are the common dunnart (*Sminthopsis murina*), the only recorded specimen for many years; *Saiphos equalis*, a skink traditionally associated with forests and heaths, and never before recorded in grasslands; and birds that have had significant declines in range, such as the ground cuckoo-shrike (*Coracina maxima*) and the Australian bustard (*Ardeotis australis*). An interesting record of an invertebrate was a currently unnamed and undescribed native land snail discovered on a stock route. This species had previously been recorded only further west, at Roma and Mitchell.

The project has also recorded information relating to seasonal patterns: heavy rainfall during December 2001 allowed the grassland remnants to be used as a refuge and breeding ground for waterfowl. The twenty species of waterfowl recorded included a pair of plumed whistling-ducks (*Dendrocygna eytoni*) that raised three young in a nest of grasses on a stock route reserve. The wet conditions of late 2001 were also favourable for frogs: the ten species recorded included the salmon-striped frog (*Lymnodynastes salmini*) and eastern metal-eyed frog (*Neobatrachus sudelli*).

Providing remnants with a more secure future is being encouraged through cooperative arrangements with land managers. One thousand hectares of native grassland on stock routes and road reserves and other reserves in the area is being managed by state and local governments.

Area revegetated

Habitat restoration for nature conservation has occurred primarily through revegetation programs undertaken by community groups. Revegetation is a major objective of the Natural Heritage Trust, non-government organisations such as Greening Australia Queensland, the North Queensland Afforestation Association, GreenFleet and Conservation Volunteers, and many smaller community groups.

The Annual Report for the Natural Heritage Trust Queensland for 2000–01 (Petith 2001) documents the delivery and implementation of the programs for Queensland. The Natural Heritage Trust supported 454 projects in Queensland, providing just under $35 million in Commonwealth funds in the 2000–01 round. The Landcare and Bushcare programs are the principal initiatives through which revegetation activities were implemented. Improved management of remnant vegetation has also occurred, as have education, information exchange and extension efforts. In all, over 84 000 ha of remnants have been protected by on-ground works (such as fencing), an additional 13 000 ha of remnant vegetation has been rehabilitated, and over 15 000 ha of revegetation has taken place on predominantly cleared areas.

Remote sensing is used to detect woody vegetation, but it cannot establish the purpose, extent, structural complexity or dominant species of revegetated areas (Kuhnell et al. 1998). The detection of woody vegetation cover is used to assess the extent of vegetation clearing as well as new areas of woody regrowth or replanting (figure 7.5). The remote sensing techniques do not discriminate well between areas of vigorous regrowth and green pasture (DNR 2000). As techniques improve, it may be feasible to report on areas of regrowth and compare these areas with revegetation and restoration projects.

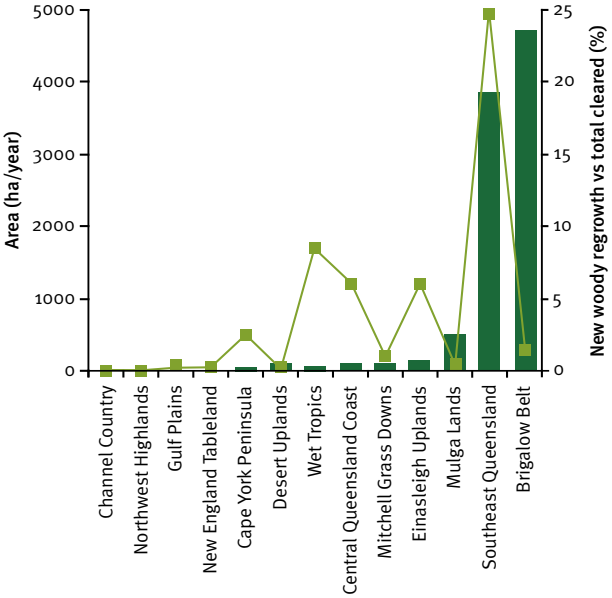


Figure 7.5 *Rate of new woody regrowth (ha/year) in the period 1997–99, detected using satellite imagery*
Source: DNR 2000



Thousands of hectares of cleared land have been revegetated. (Photo: EPA)

Marine and estuarine protected areas

Coastal and marine reserves are declared under the *Great Barrier Reef Marine Park Act 1975* (Cwlth) and Queensland's *Marine Parks Act 1982* and *Fisheries Act 1994*. A bioregional framework based on fourteen marine bioregions assists in planning and monitoring the effectiveness of the reserve network. (See also Chapter 6, 'The Coastal zone'.)

Table 7.8 shows the representation of marine and estuarine areas in marine parks. Since 1999, one new marine park totalling 38 500 ha has been added to the Wet Tropic Coast marine bioregion. Planning for a new marine park in the northern part of the Great Sandy region is also in progress.

Table 7.8 Representation of Queensland marine bioregions in marine parks

Marine bioregion	Total area, excluding islands (ha)
Carpentaria	10 833 640
Central Reef	3 138 890
East Cape York	1 445 810
Karumba–Nassau	5 614 000
Lucinda–Mackay Coast	1 510 220
Mackay–Capricorn	5 491 170
Pompey–Swains	5 637 320
Ribbons	4 781 180
Shoalwater Coast	2 030 060
Torres Strait	3 575 000
Tweed–Moreton	3 364 010
Wellesley	2 164 020
West Cape York	2 166 300
Wet Tropic Coast	581 468

Natural resource management planning

The Vegetation Management Act requires regional vegetation management plans to be prepared in consultation with regional communities. Twenty-four regional vegetation management plans, based on the bioregions of Queensland and covering the entire state, are being drafted by regional vegetation management committees. The plans will contain practical and locally relevant guidelines for vegetation management, including criteria for approved land clearing on both freehold and leasehold land. Each committee is being provided with technical support and the most up-to-date scientific information on vegetation management relevant to the region. Links are being established between regional vegetation management plans and other natural resource plans in existence or under development. The plans will be finalised and gazetted following a period of public consultation.

Planning associated with the second phase of the Natural Heritage Trust (NHT2) and the National Action Plan for Salinity and Water Quality (NAPSWQ) is under way. Biodiversity conservation is recognised as one of the major objectives of the NHT2 that will guide the allocation of funds to regional natural resource management bodies. Under the NAPSWQ, there is also scope for positive outcomes for biodiversity through mechanisms such as determination of targets for the extent and condition of native vegetation.



Sugar glider (Photo:EPA)

Species protection

Summary

Rare and threatened taxa—increasing in number

Since 1999, the number of taxa listed as rare or threatened under the Nature Conservation Act has increased; 251 plant taxa and five animal taxa have been added to the lists. Threatening processes such as high vegetation clearing rates, habitat fragmentation, weed invasion and land use intensification are of continuing concern for the maintenance of biodiversity in Southeast Queensland, and new concerns are flagged for the Brigalow Belt.

The listing of rare and threatened species is limited by the poor state of knowledge of most taxonomic groups other than vertebrate animals and vascular plants. Five freshwater fish are listed as threatened.

Recovery planning and management actions—demonstrating improvements

Population monitoring for selected species has enabled the impact of management actions to be measured, or provided the impetus for increased management intervention. The introduction of turtle excluder devices on trawlers and the proclamation of marine parks may have contributed to a decrease in the rate of decline of loggerhead turtles. Counts of migrating humpback whales in Queensland waters reveal continuing population increases.

Recovery plans have been prepared for 14% and implemented for 10% of the threatened plants and animals listed under the Nature Conservation Act, mostly for animal species. There are many examples of improvements in population and range for the animals for which recovery plans exist. These demonstrate the need for continued investment in recovery planning.



Bridled nailtail wallabies have benefited from captive breeding and wildlife management programs. (Photo: EPA)

Summary of condition and trend indicators

Recovery plans

Terrestrial bioregions	Number of rare and threatened taxa
Northwest Highlands	▼
Gulf Plains	▼
Cape York Peninsula	▼ PE, V, R ▲ E
Mitchell Grass Downs	▼
Channel Country	▼
Mulga Lands	▼
Wet Tropics	▼ PE, V, E ▲ R
Central Queensland Coast	▼
Einasleigh Uplands	▼
Desert Uplands	▼
Brigalow Belt	▼
Southeast Queensland	▼
New England Tableland	▼ E ▲ R — PE, V
Marine bioregions	▼ E ▲ V, R — PE

Key to condition:

- **Good** ‹3% of the bioregion's listed species are considered rare or threatened
- **Moderate** 3–5% of the bioregion's listed species are considered rare or threatened
- **Poor** ›5% of the bioregion's listed species are considered rare or threatened
- **Not assessed**

Key to trend:

- ▼ Degrading
- ▲ Improving
- ? Uncertain
- — No change
- x Not assessed

Trend levels are based on the change in number of rare and threatened species since 1998. Increased numbers are interpreted as degrading and decreased numbers as improving. Superscript reflects varying trends in rare (R), vulnerable (V), endangered (E) or presumed extinct (PE) taxa.

Pressures

Pressure indicators for habitat protection and introduced species are also relevant to species protection. These include native vegetation clearing rates, the extent and condition of native vegetation, altered fire regimes, pollution, diseases, hunting, invasive exotic weeds and feral predators.

Condition and trends

Rare and threatened taxa

Taxa currently scheduled under the Nature Conservation Act are almost entirely restricted to vascular plants and vertebrate animals. This situation reflects the poor state of knowledge of most other taxonomic groups and is a common deficiency of such schedules (Burgman 2002).

Assessment of trends based on the number of taxa listed as threatened needs to be undertaken carefully. The number of taxa listed as threatened (presumed extinct, endangered, vulnerable) or rare may increase or decrease for a range of reasons:

- more taxa are at risk;
- new species are discovered (Forster 2000; Bean and Jessup 2000);

- taxonomic research leads to improved definition of taxa (Henderson 2002);
- recovery actions have improved the conservation status of taxa; or
- the ecology and distribution of taxa are better understood.

The number of taxa listed under the *Nature Conservation (Wildlife) Regulation 1994* has varied since 1999, when figures were based on the schedules reprinted in April 1998. The changes are summarised in table 7.9. In summary:

- Queensland now has 29 plant and six animal species listed as presumed extinct;
- nine presumed extinct plant species are new listings since 1998, and one (*Lindsaea pulchella* var. *blanda*) was formerly listed as vulnerable;
- additions to the lists of rare and threatened species since 1998 include 251 plant taxa and five animal taxa;
- deletions from the list include 134 plants and 10 butterflies (no longer listed as rare or threatened). Reassessments indicate that the status of these butterflies is more secure than previously indicated;
- new information extended the known distribution of the rare mouse bush (*Homoranthus melanostictus*), so that it is no longer considered rare or threatened;
- one presumed extinct plant taxon, *Prostanthera clotteniana*, is now assessed as endangered and another, *Lindsaea repens* var. *lingulata*, is no longer listed as rare or threatened;
- other taxa are now more at risk. For example, concerns about the health of remaining populations of the rhizomatous herb *Solanum papaverifolium* led to its listing as endangered; and
- recently listed animals include two endangered and three vulnerable taxa. The grassland earless dragon (*Tympanocryptis pinguicolla*) is now at risk of extinction, and has been listed as endangered.

The majority of rare and threatened animal and plant taxa, including many endemics, are found in four terrestrial bioregions—Wet Tropics, Brigalow Belt, Southeast Queensland and Cape York Peninsula (figures 7.6 and 7.7). Approximately 40% of listed animals and 30% of listed plants occur in Southeast Queensland (figure 7.8). The Wet Tropics, Southeast Queensland and Brigalow Belt bioregions combined account for 70% of plants and 73% of animals that are rare or threatened.





Epping Forest National Park (Scientific) in the Brigalow Belt is home to the endangered northern hairy-nosed wombat. (Photos: EPA)

Table 7.9 Conservation status of native plants and animals listed in April 1998 and currently (2002)

Taxonomic group	Presumed extinct		Endangered		Vulnerable		Rare		Total	
	1998	2002	1998	2002	1998	2002	1998	2002	1998	2002
Mammals	5	5	12	13	20	21	31	29	68	68
Birds	1	1	11	11	22	26	31	31	65	69
Reptiles	0	0	4	7	15	14	64	63	83	84
Amphibians	0	0	14	13	6	11	25	22	45	46
Fish (bony, freshwater)	0	0	3	3	2	2	0	0	5	5
Butterflies	0	0	7	2	10	5	0	0	17	7
Total animal taxa	**6**	**6**	**51**	**49**	**75**	**79**	**151**	**145**	**283**	**279**
Angiosperms	12	18	70	130	220	251	659	661	961	1060
Gymnosperms			3	8	12	12	9	9	24	29
Pteridophytes	9	11	8	11	12	14	36	40	65	76
Algae						1				1
Total plant taxa	**21**	**29**	**81**	**149**	**244**	**278**	**704**	**710**	**1050**	**1166**

Note: Plant taxonomic names given in schedules were updated according to Henderson (2002). The numbers represent taxa (subspecies, varieties) and populations (where status differs).

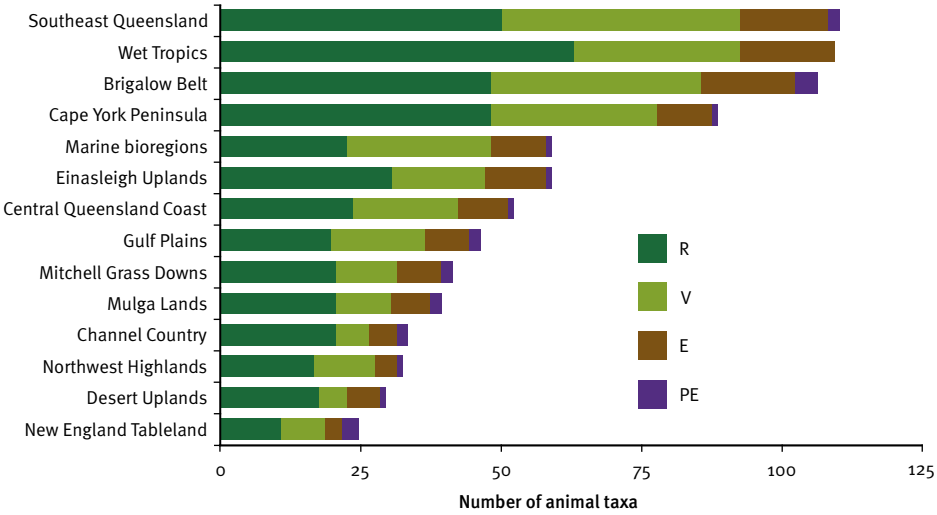


Figure 7.6 *Number of rare (R), vulnerable (V), endangered (E) and presumed extinct (PE) animal taxa in bioregions*

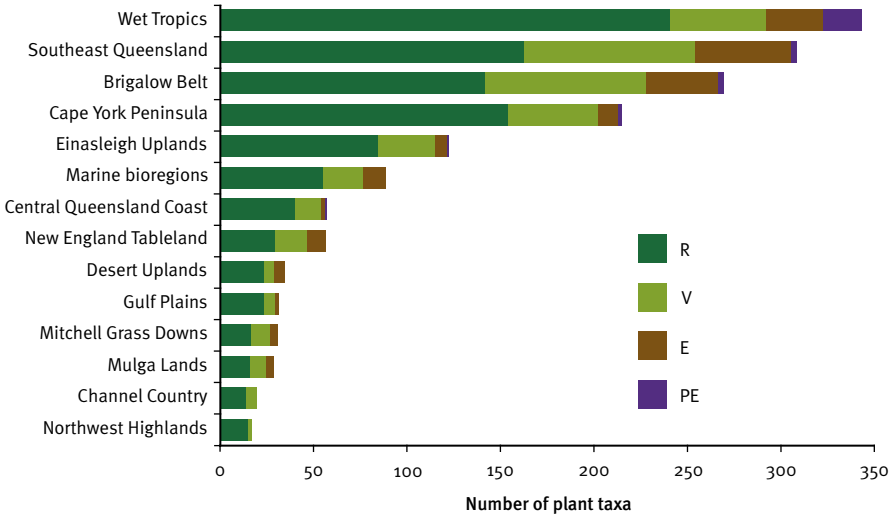


Figure 7.7 *Number of rare (R), vulnerable (V), endangered (E) and presumed extinct (PE) plant taxa in bioregions*

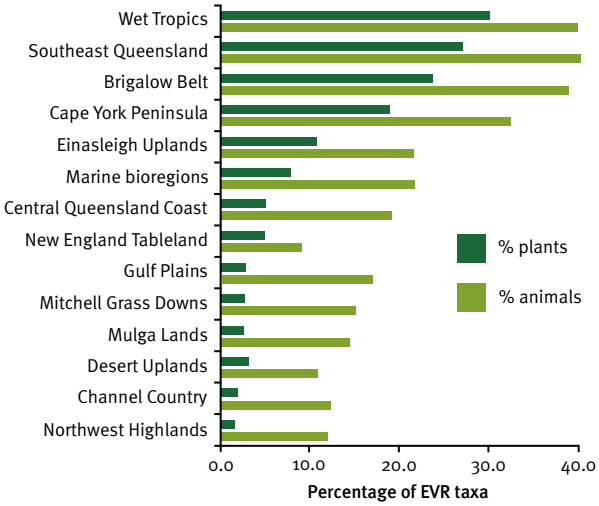


Figure 7.8 *Percentage of endangered, vulnerable and rare plant and animal taxa in bioregions*

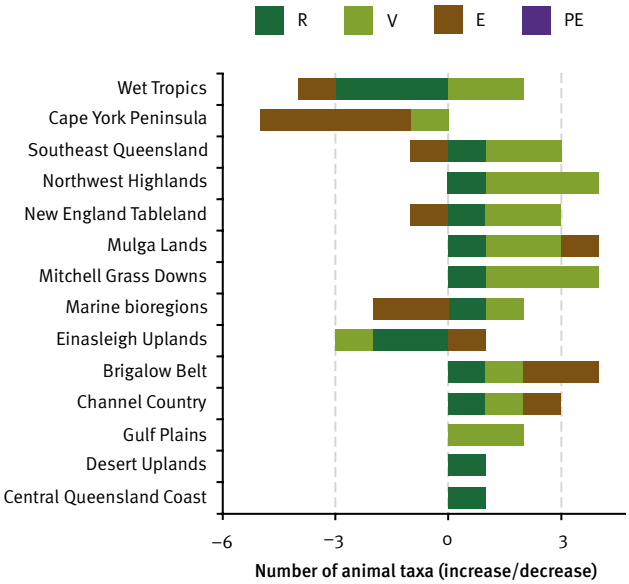


Figure 7.9 *Trend (1998 to 2002) in number of rare (R), vulnerable (V), endangered (E) and presumed extinct (PE) animal taxa in bioregions. Bioregional lists of taxa were extracted from WildNet on 2 September 2002. The trend is calculated as the difference (2002 minus 1998).*

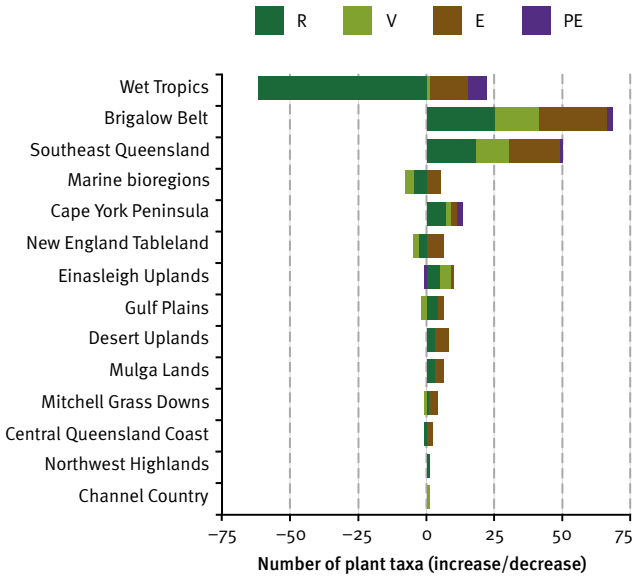


Figure 7.10 *Trend (1998 to 2002) in number of rare (R), vulnerable (V), endangered (E) and presumed extinct (PE) plant taxa in bioregions. Bioregional lists of taxa were extracted from WildNet on 2 September 2002. The trend is calculated as the difference (2002 minus 1998).*

Figures 7.9 and 7.10 show changes in the number of rare or threatened animal and plant taxa for each bioregion since 1999. These trends highlight those bioregions where rare and threatened taxa are most at risk. Threatening processes, such as vegetation clearing, fragmentation of remnants, weed invasion and land use intensification, are of continuing concern for the maintenance of biodiversity in Southeast Queensland, and of increasing concern in the Brigalow Belt.

Five freshwater fishes are listed as threatened under the Nature Conservation Act. Some other aquatic species of conservation concern in Queensland (for example, the grey nurse shark) are currently managed under the *Fisheries Act 1994*. In 1999, the Australian Society for Fish Biology listed 14 threatened species with Queensland occurrences: four endangered, three vulnerable, one potentially threatened and six restricted (Jackson 1992; Wager and Jackson 1993). Currently, 21 aquatic species with distributions in Queensland are listed as threatened (five critically endangered, seven endangered, and nine vulnerable) by the Australian Society for Fish Biology (Crook and Pogonoski 2001) and the Action Plan for Marine and Estuarine Fishes (Pogonoski et al. 2002).

All marine mammals, reptiles and birds are protected under the Nature Conservation Act. Under the Fisheries Act, fishes that are of particular scientific and conservation interest or that are targeted by commercial or recreational fishers and require management controls may be regulated by species, condition, sex and location. Species protected under the Fisheries Act include the Queensland lungfish (*Neoceratodus forsteri*), great white shark (*Carcharodon carcharias*) and grey nurse shark (*Carcharias taurus*), the giant clams (*Tridacna* and *Hippopus* spp.), giant triton shell (*Charonia tritonis*) and helmet shell (*Cassis cornuta*).

Case study: Grey nurse shark—a critically endangered species

The Australian distribution of grey nurse sharks (*Carcharias taurus*) is now confined to coastal waters off southern Queensland and New South Wales, and off the south-west coast of Western Australia. The east and west coast populations are geographically isolated as the species migrates only north–south within a limited range. The east coast population is thought to extend from Wolf Rock off Double Island Point in Queensland to Montague Island off Narooma in New South Wales. The east coast population is estimated to comprise fewer than 500 individuals.

The critical decline in their numbers has been recognised by the International Union for the Conservation of Nature and Natural Resources (IUCN), which has listed grey nurse sharks as globally vulnerable. The east coast populations are listed as critically endangered under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*. It has been illegal to take and possess grey nurse sharks or any of their products from Queensland waters since 1997.



Grey nurse sharks are threatened by a range of processes. This individual has a fishing hook caught in its jaws. (Photo: C. Roelfsema)

The Queensland Government has taken strong action to protect grey nurse sharks in Queensland waters. On 19 December 2003, management arrangements came into effect to reduce the risk of incidental capture and disturbance at four key aggregation sites in Queensland waters. All forms of fishing and aquarium collection are prohibited off Wolf Rock near Double Island Point and nearly all forms of fishing are banned, with limited exemptions, at Flat Rock, Henderson Rock and Cherub's Cave in the Moreton Bay Marine Park. The prohibitions extend to a 1.2 kilometre radius of each site and they are the most comprehensive measures for grey nurse shark protection in Australian waters to date.

The grey nurse shark is now listed under Queensland's *Nature Conservation Act 1992* as an endangered animal, which is the highest threat category for animals surviving in the wild. There are also new diving regulations at Cherub's Cave, Henderson Rock and Flat Rock to further reduce the risk of disturbance to this placid species.

Populations of selected species

Estimating population size is one way of measuring the impact of management actions and of identifying potential changes in genetic diversity. Other than measuring abundance, population monitoring can also include assessing changes in range and demographics. The inference is that any decline in distribution or departure from normal age structure represents a potential loss of individuals or subpopulations resulting in a decrease in genetic diversity. Such localised declines have been noted in the brown treecreeper (*Climacteris picumnus melanotus*) on Cape York Peninsula and eastern populations of the woma (*Aspidites ramsayi*) in the southern Brigalow Belt (Garnett and Crowley 1995; Covacevich and Couper 1996).

The species and communities discussed in this chapter were selected largely by data availability; that is, species that have been monitored for more than ten years are discussed. Most programs in which abundance is measured involve animals. There are no comparable studies using plants; any long-term surveys deal more with temporal changes in extent (Queensland Herbarium vegetation mapping) or composition/structure of various communities (DNRM forest and rangelands plots).

Surveys of marine turtles in Queensland are a valuable example of the usefulness of long-term population monitoring. Estimates of loggerhead turtle (*Caretta caretta*) numbers both on Wreck Island and at Mon Repos show a decrease in the rate of decline. The changes are probably due to the introduction of turtle exclusion devices (TEDs) on trawlers working the surrounding waters and the proclamation of Woongarra Marine Park respectively. Torres Strait harbours the last major hawksbill turtle (*Eretmochelys imbricata*) population. Counts from Milman Island show an annual fall in numbers of 3–4%. The main threatening processes affecting hawksbills include harvesting in neighbouring countries. By comparison, green turtle (*Chelonia mydas*) numbers in the southern Great Barrier Reef have stabilised but exhibit dramatic fluctuations from year to year associated with La Niña–El Niño cycles. However, turtle numbers alone may obscure a growing concern. Population modelling, using accumulated demographic data, indicates an age structure typical of a population in decline. This decline will continue unless management actions are taken and monitoring continues.



The introduction of turtle excluder devices and the proclamation of Woongarra Marine Park appear to be stabilising the population of loggerhead turtles. (Photo: EPA)



Humpback whale numbers are recovering following the cessation of commercial whaling. (Photo: EPA)

Counts of migrating humpback whales (*Megaptera novaeangliae*) in Queensland waters reveal an increasing population (figure 7.11). Numbers continue to recover following the cessation of commercial whaling. However, the increasing polarisation of members of the International Whaling Commission and growing pressure to resume commercial whaling operations still pose significant risks to whale recovery.

East coast dugong (*Dugong dugong*) populations have fluctuated over the years the animals have been surveyed, numbers being high in 1986–87 and 1999 but considerably lower in 1994. The differences are attributed to many factors, including the establishment of dugong protection areas, hunting bans, variable sighting conditions and large-scale movements of dugongs in response to seagrass availability (Marsh and Lawler 2001). Historically, the southernmost population (Moreton Bay) has had large changes in numbers due to hunting and occasional reduction in seagrass meadows. Despite the relatively intense use of the bay, the population appears resilient. Recent surveys indicate sizeable populations in the remainder of the species' Queensland distribution.

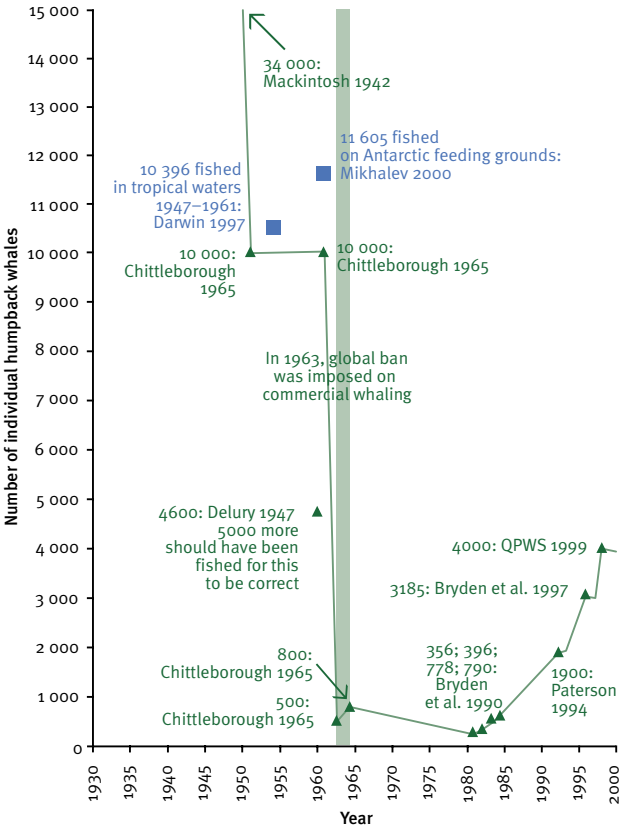


Figure 7.11 *Changes in the abundance of humpback whales*
Source: Vang 2002

The accumulated Birds Australia bird atlas data (1977–81, 1999–2001) provide a substantial information source, which, when analysed, can indicate trends in avifauna populations. There is scope for assessing individual taxa or combining taxa into recognised communities or guilds to determine the need for action (Garnett and Crowley 2000). Certain woodland breeding birds—brown treecreeper (*Climacteris picumnus*), hooded robin (*Melanodryas cucullatta*) and diamond firetail (*Stagonopleura guttata*) in the southern section of the Brigalow Belt and in the Desert Uplands—appear to be less common, but the overall reporting rate for woodland birds as a group appears unchanged (Garnett 2001; Barrett et al. 2002). There is also concern for the granivorous birds, such as certain finch species and the flock bronzewing (*Phaps histrionica*) of the tropical grasslands (Franklin 1999). The apparent declines in woodland, grassland and ground-nesting species and guilds vary across the bioregions, depending on the type and extent of certain threatening processes operating in each bioregion (Garnett et al. 2002).

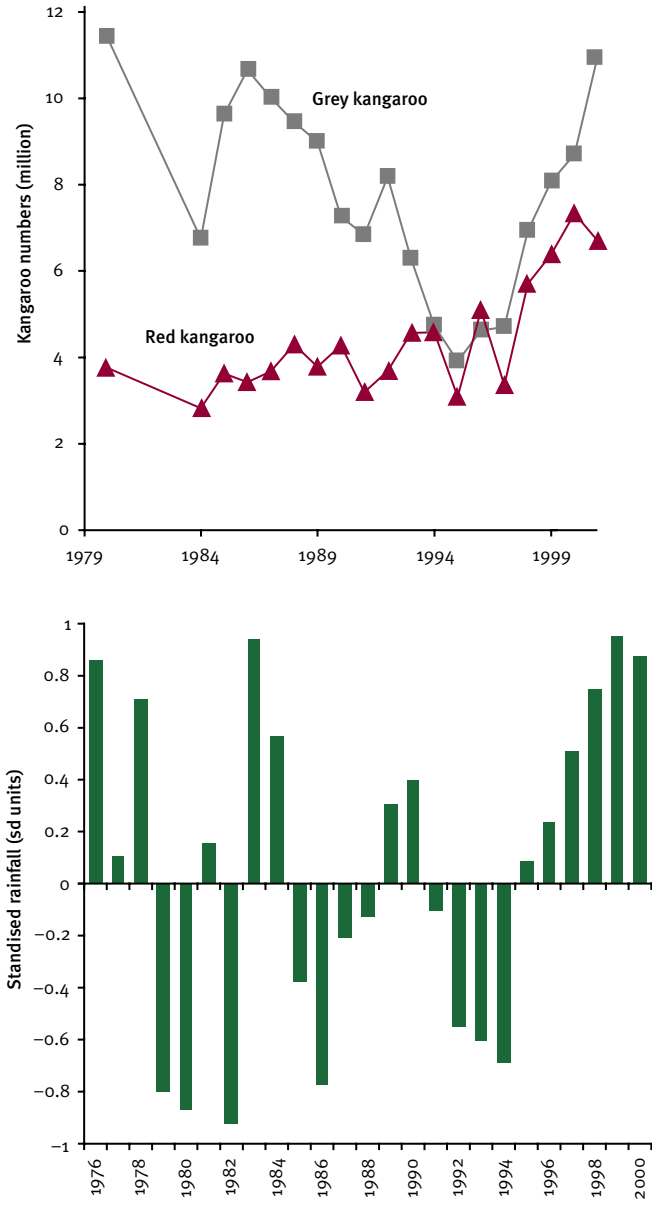


Figure 7.12 *Changes in estimated kangaroo numbers in Queensland 1980–2000 and standardised rainfall over the same period*
Source: Pople, The University of Queensland

Since the early 1980s, populations of commercially harvested kangaroos have been estimated in Queensland over an area of approximately 1.5 million square kilometres. Aerial surveys have been conducted annually in a core area covering much of the southern Brigalow Belt, Mulga Lands and Mitchell Grass Downs bioregions. Populations of common wallaroos (*Macropus robustus*), eastern grey kangaroos (*M. giganteus*) and red kangaroos (*M. rufus*) have increased since the mid-1990s (figure 7.12). Fluctuations in numbers have been consistent with rainfall patterns within the core survey area and a recent decline in harvest rates. A conservation and management plan exists for commercially taken macropods (QPWS 2000).

Surveys of estuarine crocodiles (*Crocodylus porosus*) since 1979 show that the north-west part of Cape York remains a stronghold for the species in Queensland, though there is some concern for populations in the northern Gulf Plains (Messel et al. 1981; Taplin 1991; Read et al. in prep.). Crocodile density in the more populated Wet Tropics remains low (table 7.10). Estimates vary considerably between years and river systems.

Table 7.10 Number (mean) and range of non-hatchling crocodiles seen per kilometre of waterway surveyed in the Wet Tropics

Years	Mean	Range
1984–86	0.36	0.06–0.75
1996–98	0.34	0.12–1.0
1998–2000	0.5	0.4–0.6

Sources: Taplin 1991; Kofron and Smith 2001; Read et al. in prep.



Cape York is a stronghold for estuarine crocodiles in Queensland. (Photo: EPA)

Surveys of migratory waders have been conducted by the Queensland Wader Study Group at various sites around the Queensland coastline. The timing ranges from monthly for locations between Tweed Heads and Cairns to every few years for more remote places, such as the south-east Gulf of Carpentaria. No significant changes in total numbers of birds visiting the south-east Gulf or the Great Sandy Strait have been recorded since 1999 (Driscoll 1998, 2001).



The number of migratory waders visiting Queensland appears to be stable. (Photo: L. Knight, EPA)

Responses

Recovery plans

Recovery plans are an important response to the decline in biodiversity and can be prepared and funded by state or Commonwealth agencies or other interested parties, such as the World Wide Fund for Nature.

Of the 588 threatened plants and animals listed under the Nature Conservation Act, recovery plans have been prepared for 14% and approved for 10% (table 7.11). The vast majority of plants (97%) do not have recovery plans. Efforts have been directed toward more community-based planning, such as the draft recovery plan for Southeast Queensland Rainforest, which encompasses a suite of threatened taxa. Nearly half of the threatened animals have recovery plans and, again, efforts have been aimed at developing multiple-species plans (Northern Queensland Threatened Frogs Recovery Team 2001a, 2001b). In some instances, such plans are used to promote broader landscape conservation involving landholders. For example, the draft brigalow reptile recovery plan emphasises the need to protect threatened ecosystems such as remnant native grasslands on the Darling Downs (Drury 2002). Similarly, the need for appropriate fire regimes on Cape York Peninsula is not just a requirement for golden-shouldered parrots (*Psephotus chrysopterygius*) (Garnett and Crowley 1999) but for a whole suite of taxa in the wet-dry tropical savannas that have declined since settlement (Franklin 1999, 2000).

There has been a significant increase in the number of recovery plans prepared and approved for threatened animals since 1999. In 1999, 40 plans had been prepared (for 30% of threatened taxa) and 31 had been approved (covering 23% of threatened taxa). In 2002, 66 plans (49% of threatened taxa) had been prepared and 48 (36% of threatened taxa) had been approved. In addition, several plans either have been or are being developed for taxa currently listed under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) that occur in Queensland but at the time of writing are not scheduled under the Nature Conservation Act, such as the grey-headed flying-fox (*Pteropus poliocephalus*), grey nurse shark, Mary River cod (*Maccullochella peelii mariensis*) and Lake Eacham rainbowfish (*Melanotaenia eachamensis*).

Recovery plans have had some significant outcomes:

- in the period 1999–2001, SEQ Rainforest Recovery project achievements included the construction of over 24 km of fencing and the establishment of 30 conservation agreements (Hyslop 2002; Van der Gragt, pers. comm.);
- as the result of a joint project by several south-east Queensland local governments (Logan, Redland, Gold Coast, Brisbane and Ipswich), the known population of the endangered angle-stemmed myrtle (*Gossia gonoclada*) has increased from 73 individuals to 285 in the past six years;
- establishment of the Zillman Scientific Area, west of Childers, has resulted in the protection of the main population of *Alectryon ramiflorus*;
- a predator-exclusion fence was completed at Currawinya National Park to allow the creation of a new greater bilby (*Macrotis lagotis*) population;



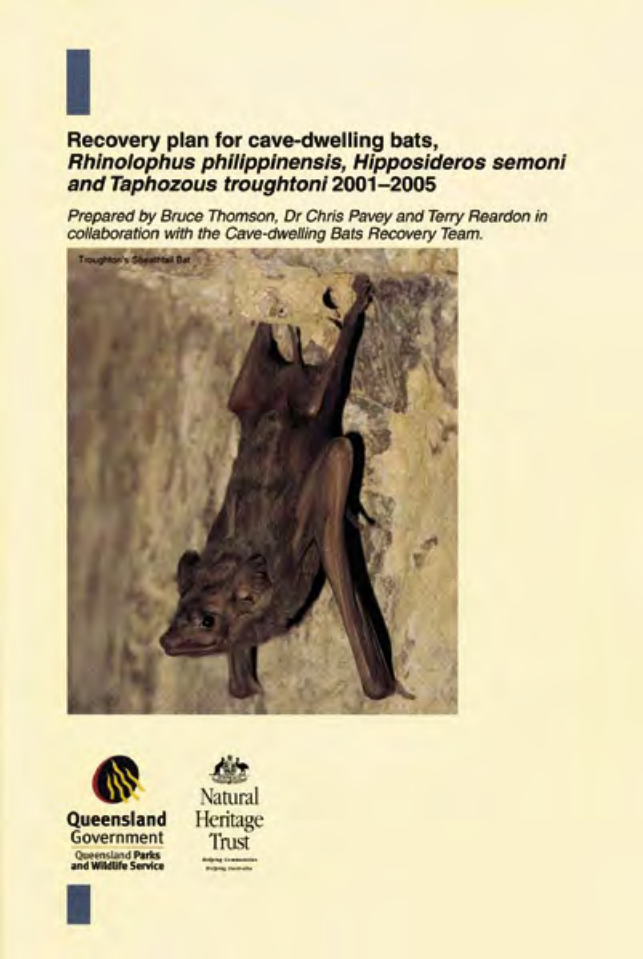
Appropriate fire regimes are needed to provide a suitable habitat for golden-shouldered parrots. (Photo: EPA)



A two-metre high predator exclusion fence provides a safe habitat for bilbies at Currawinya National Park. (Photos: EPA)

- captive breeding and release of bridled nailtail wallabies (*Onychogalea fraenata*) and management of the natural population have seen an increase in numbers both of individuals, from 366 in 1997 to 1398 in 2000, and of populations, from six in 1997 to eleven in 2000. Broader community support has been engaged in establishing several new translocated populations, for example, at the Avocet Nature Refuge and Gregory mine site (Lundie-Jenkins, pers. comm.);
- the historical decline of 14 species of rainforest stream frogs in northern, central and southern Queensland has been well documented (Hines et al. 1999; McDonald and Alford 1999; EPA 1999). These declines have been rapid and present monitoring indicates that six species may be or are likely to be extinct (McDonald 2002). Among the remaining threatened frogs, monitored populations have fluctuated but all species are persisting. In most instances where numbers have risen, rises were due to the detection of new populations or natural increases rather than recovery of known populations through direct intervention (Freeman 2001; Hero et al. 2002; Hines, pers. comm.); and
- actions to protect the northern hairy-nosed wombat (*Lasiorhinus krefftii*) have included the use of modern technology for collecting census data, and construction of a dingo-proof fence (Horsup 2001). The population in 2000 was estimated at 113 individuals, double the number recorded in 1993.

Most of the animal recovery plans have achieved some positive outcomes (table 7.11). The fact that the majority of plans for plants are currently inactive is a cause for concern. The only active fish plan is for a taxon (Mary River cod) not listed on the state regulation. While progress has been made, no taxon has been reclassified to a more secure conservation status through specific recovery plan actions.



The recovery plan for cave-dwelling bats 2001–2005 outlines actions required to improve the conservation status of these species.

Table 7.11 Number and proportion of threatened plant and animal taxa scheduled under the *Nature Conservation Act 1992* with recovery plans prepared or implemented at June 2002

Taxonomic group	Number of threatened taxa	Threatened taxa with a recovery plan prepared		Threatened taxa with a recovery plan approved[a]		Percentage of approved plans[b]		
		No.	%	No.	%	A	B	C
Mammals	39	15	39	13	33	69	31	0
Birds	38	11	29	7	18	2	29	29
Reptiles	21	15	71	7	33	86	14	0
Frogs	24	16	67	16	67	56	44	0
Freshwater fish	5	4	80	3	60	0	0	100
Butterflies	7	5	71	2	29	50	0	50
Animals	134	66	49	48	36	58	29	13
Plants	456	15	3	10	2	30	10	60
Total	**590**	**81**	**14**	**58**	**10**	**53**	**26**	**21**

[a]Excludes plans listed as draft documents.
[b]Excludes draft recovery plans that may be active.
A = active plan with positive outcome
B = active plan where outcomes are unknown or inconclusive
C = inactive plan

Source: EPA

Introduced species

Summary

Increasing noxious weeds

Weeds have substantial impacts on biodiversity. Queensland has 15 of the 20 species listed as weeds of national significance and many more species are serious environmental weeds. New naturalisations are reported each year.

Human activities are the main vector for both the introduction and the spread of weeds. There are many examples of weeds, both marine and terrestrial, where strategic and well-resourced quarantine activities can minimise introductions. When introductions do occur, coordinated and rapid response can result in successful eradication.

The spread of species already identified as problems can also be controlled through strategic activities. Control rather than eradication is the only appropriate response for many species already well established in Australia. Eradication is too costly and long-term in effort to attract sufficient resources.

Biological controls and active containment programs are having a major impact on some weeds including rubber vine (*Cryptostegia grandiflora*) and parthenium (*Parthenium hysterophorus*). Most established weeds in Queensland are far from under control and pose major threats to biodiversity, requiring a significant increase in investment in both control strategies and research into control techniques.

Wetland species are able to spread rapidly and control is very costly. Hymenachne (*Hymenachne amplexicaulis)* and para grass (*Brachiaria mutica*) continue to spread and invade many of the state's remaining natural wetlands. Pond apple (*Annona glabra*) is taking over timbered wetlands in central and northern coastal regions. Perennial grasses such as buffel (*Cenchrus ciliaris*) and mission grass (*Pennisetum polystachion*) are spreading rapidly, often aided by excessive grazing pressure in rangelands and woodlands or additional native vegetation clearing. Woody species including mesquite, mimosa, parkinsonia, prickly acacia, rubber vine and camphor laurel are increasing. Lantana and parthenium have the potential to colonise suitable habitat across the entire state and also continue to spread.

Increasing feral animals

The impact of feral animals on biodiversity is substantial and control techniques are generally under-resourced. Feral animals, including cats, foxes, wild dogs, rabbits, goats and pigs, have caused the decline and, in some cases, extinction of native animals through predation and competition. Strategies for integrated control are holding many populations, such as rabbits (*Oryctolagus cuniculus*), in equilibrium.

Key areas for concern are the various aquatic introductions. Despite considerable research effort, there is no effective control for cane toads (*Bufo marinus*) and they continue to expand around the fringes of their distribution, entering the extensive and substantially natural wetlands of tropical Australia. The high diversity of native freshwater fauna in Queensland is threatened by the increasing spread of carp and other exotic fish such as tilapia (*Tilapia mariae*) and gambusia (*Gambusia holbrooki*). Again, control is difficult. It is essential to eradicate new incursions where possible.

Serious new incursions such as crazy ants (*Anoplolepis gracilipes*) and red imported fire ants (*Solenopsis invicta*) are testing containment and eradication procedures across three tiers of government and diminishing the resources otherwise available to implement control strategies for established feral animals.

Continuing biodiversity loss

The implications of feral animals and weeds in terms of impacts on biodiversity are well recognised. The *Land Protection (Pest and Stock Route Management) Act 2002* states the need to control pest weeds in environmentally significant areas. The adverse impacts associated with pigs, goats, rabbits, feral cats and European red foxes have led to their listing as key threatening processes under the EPBC Act. The 2002 report on biodiversity investment opportunities to the Prime Minister's Science, Engineering and Innovation Council stressed the importance of increased investment in both quarantine for introductions and eradication and control for established weed and feral species.

Much more remains to be done, as indicated by the summary table on page 7.24. In nine of the state's thirteen terrestrial bioregions, the trend is towards continuing degradation caused by feral animals and weeds. Chapter 4, 'Land' includes a summary table of condition and trend indicators for pest animals and plants.



Lantana is an introduced ornamental plant that has the potential to colonise suitable habitat across the whole of Queensland. (Photo: EPA)



The spread of tilapia and other exotic species of fish is seriously threatening freshwater biodiversity. (Photo: Queensland Museum)

Summary of condition and trend indicators

Introduced species

Bioregion	Number of introduced species that have become naturalised
Northwest Highlands	?
Gulf Plains	–
Cape York Peninsula	?
Mitchell Grass Downs	▼
Channel Country	–
Mulga Lands	▼
Wet Tropics	▼
Central Queensland Coast	▼
Einasleigh Uplands	▼
Desert Uplands	▼
Brigalow Belt	▼
Southeast Queensland	▼
New England Tableland	▼

Key to condition:

Good	‹2 introduced taxa per 1000 ha
Moderate	2–10 introduced taxa per 1000 ha
Poor	›10 introduced taxa per 1000 ha
Not assessed	

Key to trend:

▼ Degrading
▲ Improving
? Uncertain
X Not assessed
– No change

Pressures

The distribution of feral animals and naturalised plants, some of which are already serious pests, provides an indication of pressure on biodiversity (figure 7.13). At least 1298 plants (Henderson 2002) and 19 mammals, 13 birds, 15 fishes, 3 reptiles and 1 amphibian (WildNet, September 2002) have become naturalised. Many more plants and animals have been introduced, some of which may have formed undetected breeding populations. Unknown numbers of invertebrates, fungi and bacteria have also become established.

The highest densities of introduced taxa are found in the New England Tableland, Wet Tropics, Central Queensland Coast and Southeast Queensland bioregions (figure 7.13). The greatest total numbers of introduced vascular plant and vertebrate animal taxa are found in the Southeast Queensland, Brigalow Belt and Wet Tropics bioregions.

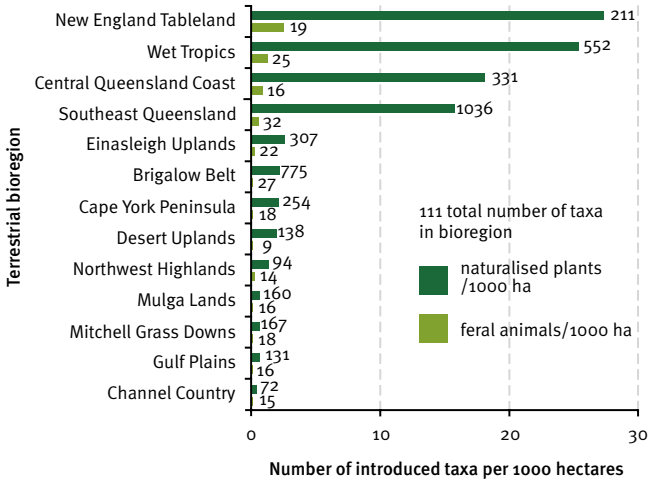


Figure 7.13 *Number of feral animals and naturalised plants and incidence per 1000 ha in each terrestrial bioregion, September 2002*
Source: EPA WildNet

Weeds—key issues and opportunities for improved control

Eighteen new plant naturalisations were recorded in Queensland in the period 1999–2001 (Queensland Herbarium 2001, 2002). Plant naturalisations in Southeast Queensland have occurred at a rate of 87 species per decade since 1900 (Batianoff et al. 2001).

Depending on the habitat type, there are key weed species that are having major impacts on biodiversity.

Within riparian areas, rubber vine is the most significant weed, with a potential distribution of 80 million ha (figure 7.14). Rubber vine crowds out native riparian species, altering the function of riparian areas both in terms of habitat and as a buffer to trap sediments and nutrients. Exclusion of grazing so that a hot fire can then be sustained seems to be one of the most cost-effective strategies for controlling rubber vine and re-establishing dominance of native riparian vegetation.

Within native grasslands, prickly acacia (*Acacia nilotica*) is a major woody weed and a serious threat to the biodiversity and integrity of the northern Mitchell Grass Downs (figure 7.15). Strategies involving the manipulation of grazing pressure and fire regime seem to provide opportunities for increased control.

Within rangelands, there is now considerable debate between pastoral and biodiversity interests about the benefits and costs of introduced grasses and pasture legumes, such as buffel grass (*Cenchrus ciliaris*) and *Stylosanthes* spp. Some regard them as valuable fodder, while others see them as invasive weeds, particularly within partially cleared to cleared rangeland grazing areas. From an ecological perspective, there are major questions about the total impact of introduced grasses. Factors such as pasture response to climate variability, soil nutrient decline, increasingly hot fires, especially associated with buffel, and changing groundwater hydrology/salinity hazard due to changed water balance are yet to be fully understood. The long-term economic benefit of replacing native perennial grasses with introduced species requires assessment.



Rubber vine has the capacity to crowd out the riparian zone. (Photo: EPA)



Prickly acacia is a major threat to biodiversity in the Mitchell Grass Downs. (Photo: EPA)

The introduction of pasture species to enhance beef production in shallow wetlands has led to major weeds becoming established and spreading, particularly hymenachne and para grass. These weeds are extending over key fisheries and waterfowl habitats, altering flood flows and threatening the natural integrity and biodiversity of many unique artesian spring habitats (Fensham and Fairfax 2002). Control strategies range in cost from extremely expensive to prohibitive. The net loss to biodiversity and fisheries values probably far exceeds the benefits to beef production and requires a more rigorous approach to reduce the spread of these weed species.

The conflict between introduced pasture species and biodiversity and fisheries values in terms of benefits and costs demonstrates the need for a more holistic approach in designating weed species and controlling their spread. Traditionally, 'weeds' were those species perceived to be a threat to agriculture. Community recognition of biodiversity and fishery values implies that agencies are reassessing what actually constitutes a weed species.

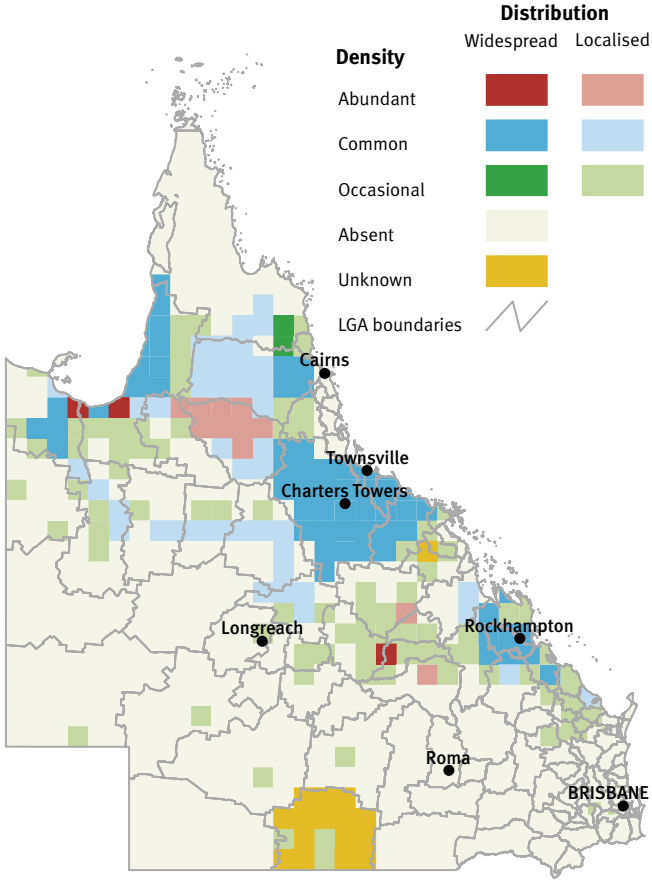


Figure 7.14 *Distribution of rubber vine, June 2003*
Source: DNRM

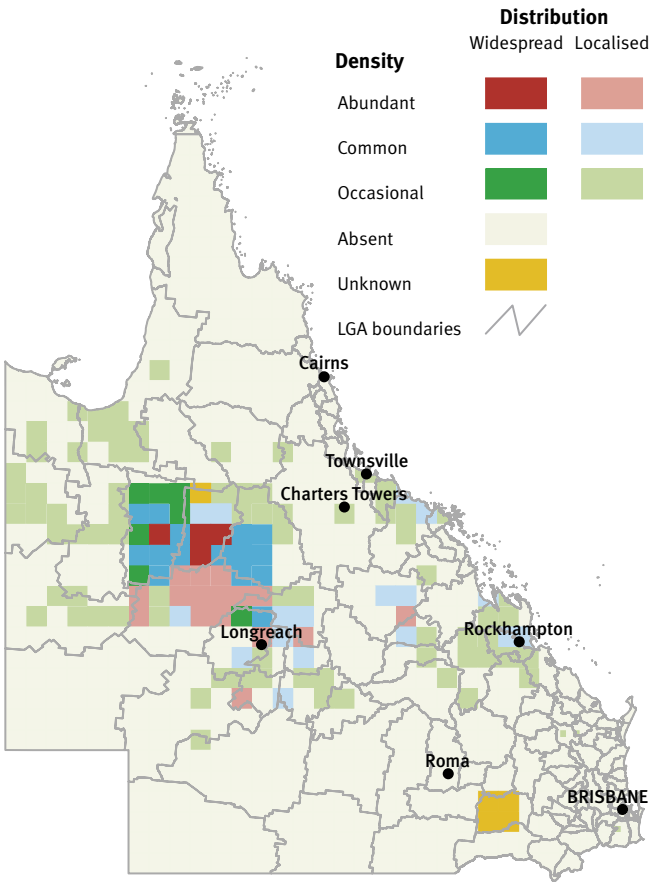


Figure 7.15 *Distribution of prickly acacia, June 2003*
Source: DNRM



The spread of buffel grass is linked to a range of ecological impacts. (Photo: EPA)

Feral animals—key issues and opportunities for improved control

Examples of the impacts of feral animals on biodiversity in Queensland (Land Protection 2002a) include:

- direct predation, especially by foxes and feral cats;
- loss of food and shelter species as rabbits, feral goats and feral pigs prevent regeneration and destroy vegetation;
- degradation of habitats with reduction in water quality (carp), introduction and spread of weed seeds (pigs), and erosion and land degradation (pigs and rabbits);
- poisoning of native animals, with cane toads implicated in the decline of native predators such as quolls and snakes;



Foxes prey on numerous species of native animals. (Photo: EPA)

- disease spread by released aquarium fish, which may be the source of exotic diseases that have been implicated in the decline of native frogs;
- competition for shelter, especially by feral bees and Indian mynahs that occupy tree hollows; and
- competition for food resources, with rabbits, feral goats and feral pigs competing directly with native species.



Feral goats contribute to vegetation decline and land degradation. (Photo: EPA)

Such impacts have resulted in selected feral animals being listed as key threatening processes under the EPBC Act. Foxes have played a major role in the decline of many small native animals since their introduction over 120 years ago (figure 7.16). Feral pigs cause serious environmental damage through wallowing and rooting for food, spreading of environmental weeds such as pond apple and predation of ground-nesting birds (figure 7.17; see also 'Ecology and management of feral pigs in tropical rainforests', page 7.29).

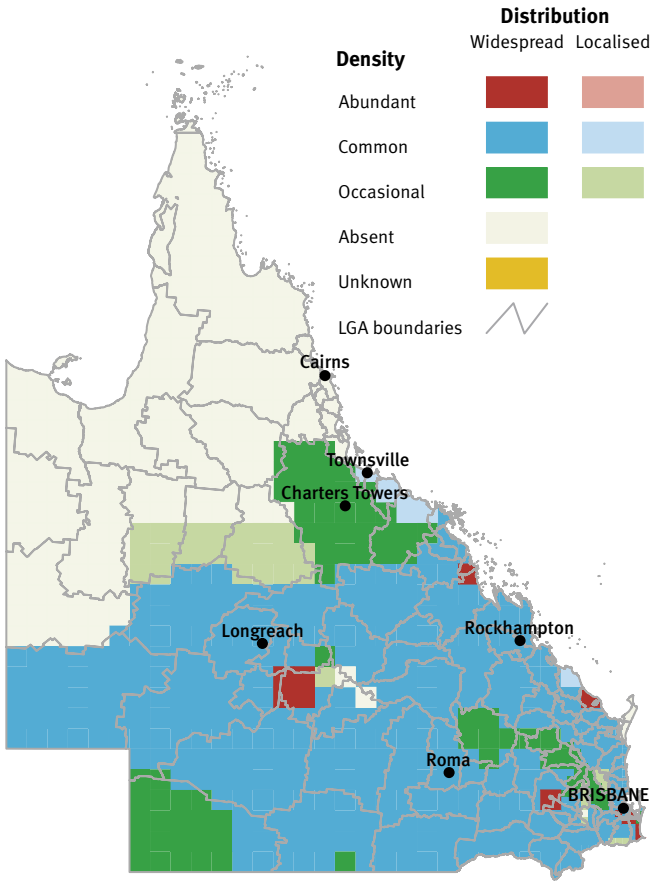


Figure 7.16 *Distribution of foxes, June 2003*
Source: DNRM

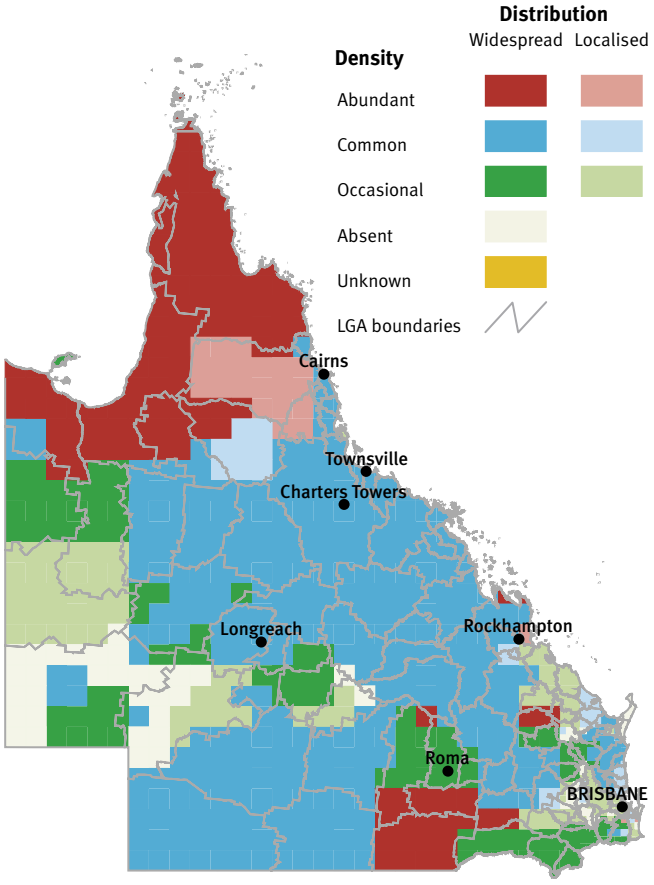


Figure 7.17 *Distribution of feral pigs, June 2003*
Source: DNRM

Case study: Ecology and management of feral pigs in tropical rainforests

Feral pigs (*Sus scrofa*) are the major pest animal in the Wet Tropics. They damage the natural environment and pose a major threat to the conservation values of the Wet Tropics World Heritage Area. A study of the ecology and management of feral pigs in tropical rainforests has recently been completed (Mitchell 2001). Feral pigs were found to have a detrimental impact on seedling survival and may affect the long-term health of rainforest communities. Pigs also cause significant losses to agricultural enterprises in the region and harbour and spread diseases affecting native animals, stock and humans.

A community-based feral pig trapping program has been under way in the Wet Tropics (Land Protection 2002b). Over 800 traps have been deployed, the majority on the interface zone between the World Heritage Area and neighbouring landholders. Since 1993–94 the program has trapped over 12 000 pigs; approximately 2000 were caught during 2000–01. This active and ongoing community control strategy is funded by a partnership across federal, state and local organisations, as well as community groups and individual landholders.



Feral pigs have a significant impact on waterways. Digging denudes creek banks, contributing to erosion and high levels of turbidity in creek water. (Photo: L. Knight, EPA)

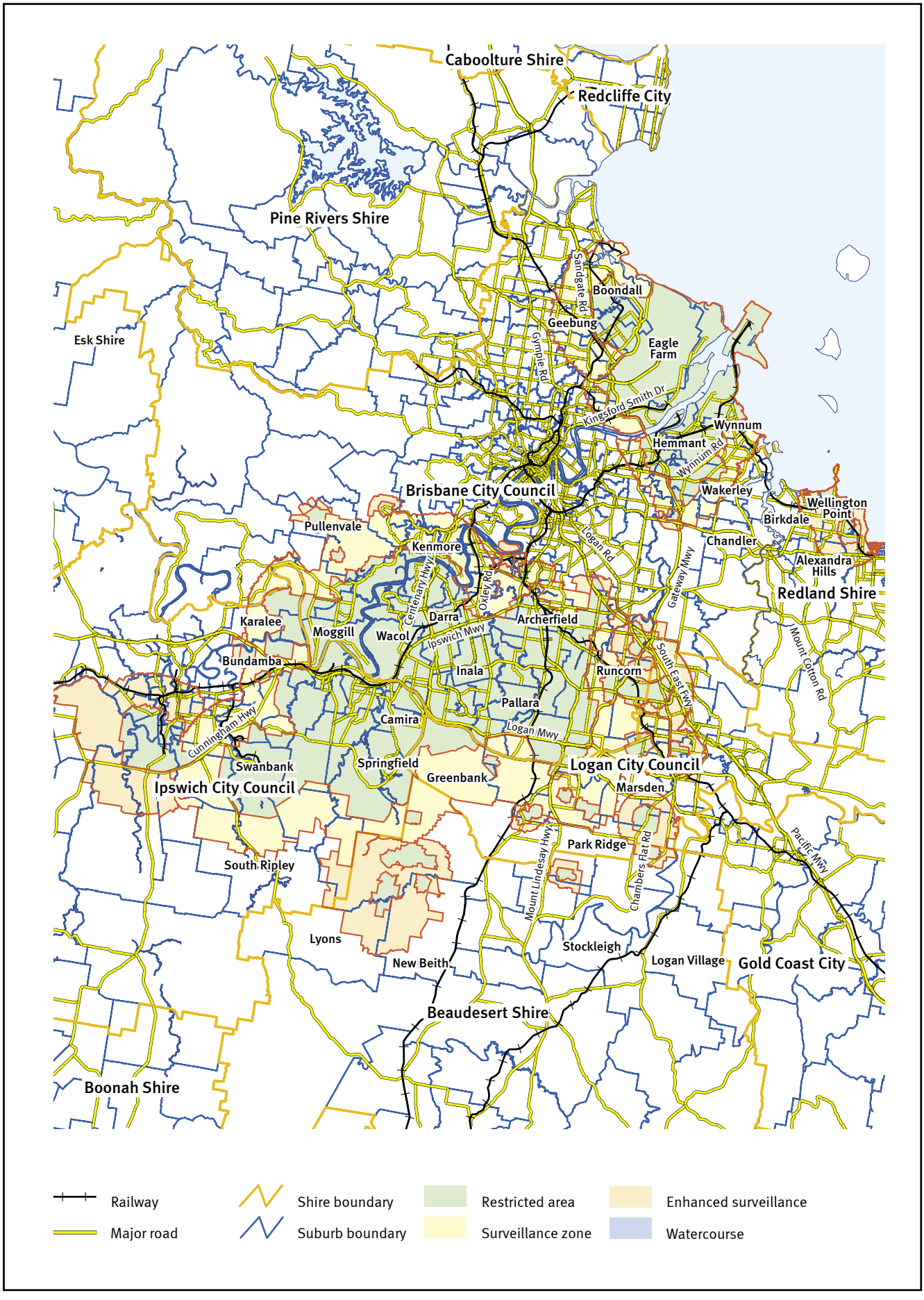


Figure 7.18 *Fire ant treatment and surveillance areas in south-east Queensland, 18 October 2002*
Source: DPI

Fish

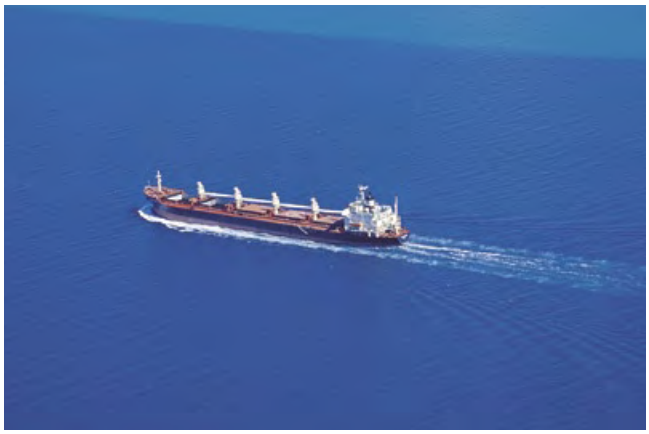
Queensland's high diversity of native freshwater fishes is threatened by the presence of introduced species. Significant pest fishes are the common carp (*Cyprinus carpio*), the group of fish species known as cichlids (Family *Cichlidae*) and mosquito fish (*Gambusia holbrooki*). Carp and cichlids are still expanding their range.

Invertebrates

Recent infestations of pest invertebrates include crazy ants (*Anoplolepis gracilipes*) and red imported fire ants (*Solenopsis invicta*). Crazy ants were discovered in Cairns (April 2001) and Townsville (February 2002). This pest appears to have been eradicated. Red imported fire ants were detected in south-east Queensland in February 2002 (figure 7.18). They pose the greatest ecological threat to Australia since the introduction of the rabbit. A large eradication program has been established with funding from other states and the Commonwealth (see Chapter 4, 'Land').

Marine exotics

The introduction of exotic marine species through the discharge of untreated ballast water from bulk carriers poses a significant threat to marine ecosystems. Exotic organisms can also be introduced in association with mariculture species (for example, mussels and oysters) and by hull fouling. At least 20 exotic marine species have been detected in Queensland waters (EPA 1999; see also Chapter 6, 'The Coastal zone'). Key strategies include better management of ballast water as international shipping enters Australian waters and 'just in time' slipping. For example, vessels from Pacific countries awaiting slipping and anti-fouling often anchor for extended periods in Cairns Harbour, providing excellent opportunities for the introduction of marine pests.



Exotic marine organisms are brought to Queensland waters on the hulls of, and in the ballast water carried by, bulk carriers. (Photo: Queensland Transport)

Increasing investment in control and quarantine

Two areas yet to be adequately regulated in Australia but that must be regarded as emerging priorities for quarantine are the introduction of pasture grasses and introductions of aquatic weeds and fish species as part of the aquarium trade. Neither of these activities is adequately assessed in terms of impacts on biodiversity before introductions occur. Both pose major threats to Australia's fauna, flora and biodiversity values. From a risk management perspective, further investment in regulatory control is warranted.

The spread of native and non-endemic species can also lead to impacts on biodiversity:

- chytrid fungus (native or non-native) has been implicated in the decline of frog species;
- translocation of native flora and fauna can have harmful consequences. Stocking of rivers with native fish outside their normal range can have impacts similar to those of exotic fish. Non-indigenous plants, such as cadaghi (*Corymbia torelliana*) and umbrella tree (*Schefflera actinophylla*) escape from gardens to become environmental weeds; and
- the impact of genetically modified organisms is not yet known.

Control represents a further area for strategic re-evaluation, adding biodiversity costs to the balance sheet to determine the most appropriate investment strategies. For example, wash-down facilities can minimise the spread of seeds and are often much cheaper to sustain than an eradication program once a weed has become established in a new region. Limiting disturbance to natural vegetation also reduces the opportunities for weeds to spread.

The challenge for biodiversity managers is to balance appropriate levels of investment for the control of pest species with the need for an adequately resourced quarantine system. Agricultural considerations and biodiversity impacts are now driving the management of pest plants and animals.

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Lawn Hill Gorge, Boodjamulla (Lawn Hill) National Park (Photo: EPA)

8 Human settlements

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Author

John Abbott, Department of Local Government and Planning

Reviewers

Dr Peter Newton, Science Director, Sustainable Built Environment, Manufacturing and Infrastructure Technology, CSIRO, Melbourne
Professor Bob Stimson, Director, Centre for Sustainable Urban and Regional Futures, The University of Queensland, Brisbane
Professor David Midmore, Institute for Sustainable Regional Development, University of Central Queensland, Rockhampton

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Introduction

Human settlements in Queensland range from isolated outback farms and Indigenous communities, rural towns and regional centres to the rapidly growing metropolis of South East Queensland. These settlements, particularly the large urban centres and cities, drive modern economies and provide a rich social and cultural environment in which people can interact and pursue a range of educational, employment and recreational opportunities. These opportunities attract more people and fuel the trend towards increasing urbanisation.

In 2001, 86.5% of Queenslanders lived in settlements that were classified by the Australian Bureau of Statistics (ABS) as urban centres or localities; that is, they had a population of more than 200 people. This figure has grown from 83% in 1991 and reflects the continuation of a long-term national and state trend towards a greater proportion of people living in urban areas. Figure 8.1 shows the size and distribution of population centres in Queensland in 2001.

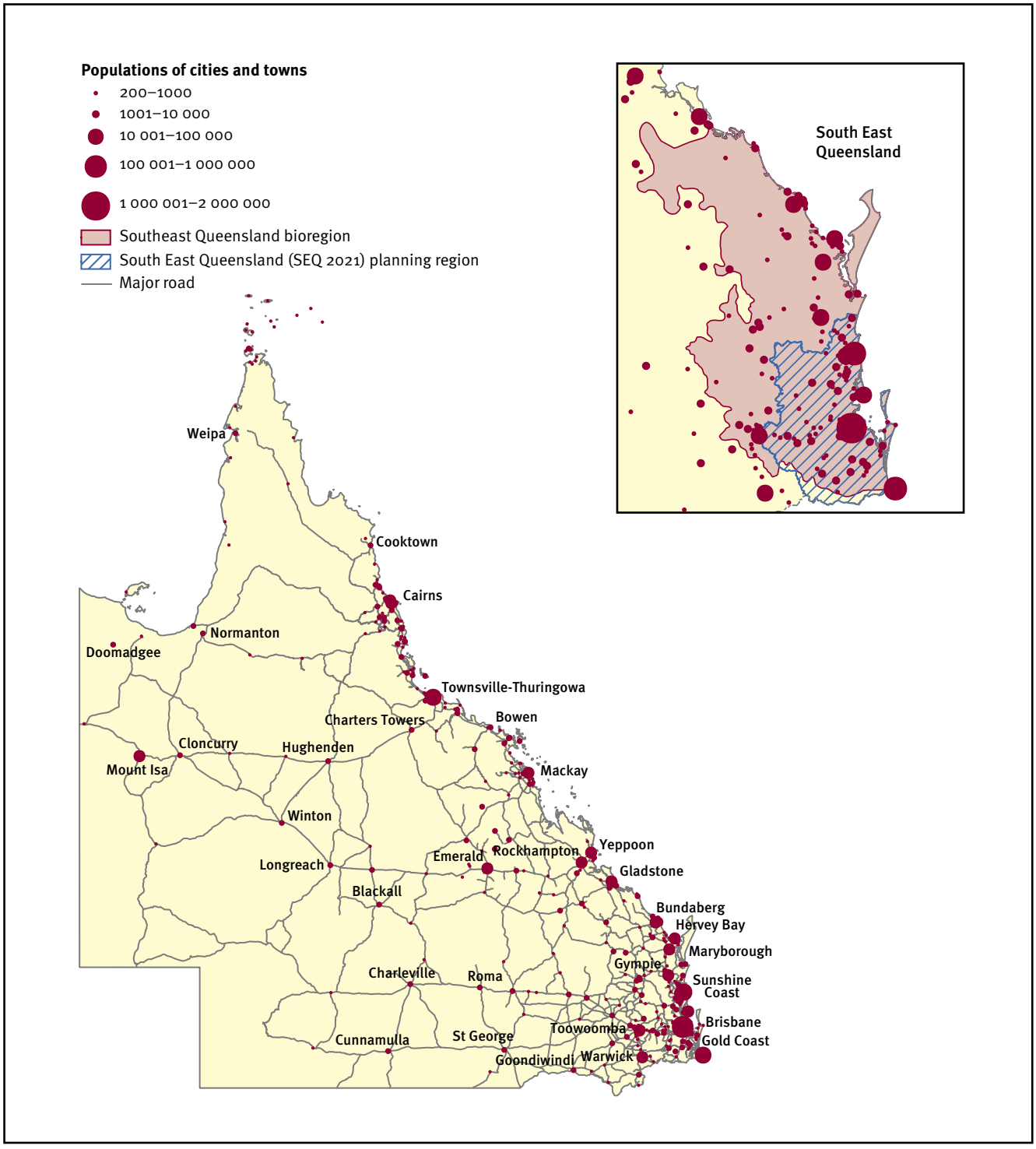


Figure 8.1 *Size and distribution of population centres in Queensland, 2001*
Source: DLGP, from ABS figures

Growing human settlements have impacts on the environment through land conversion, the development of physical and social infrastructure, and the consumption of water and energy. Local impacts include the loss of good quality agricultural land and the destruction of natural habitats. There are also wider impacts on areas some distance away from settlements. These arise from the construction of dams and power stations, and the disposal of wastes.

Human settlements do not exist or grow without constraint. They are increasingly managed through a complex set of laws and regulations. The rapid growth of Queensland's human settlements and their social, economic, infrastructure and environmental impacts have been a major concern since the early 1980s. In response, the Queensland Government initiated sweeping legislative and administrative reforms leading to the establishment of a statutory framework for the integration of planning and the management of development under the *Integrated Planning Act 1997* (IP Act) in March 1998. This reform is continuing and involves amendments to a wide range of legislation regulating and managing the growth of human settlements and the impacts of that growth.

At the core of the integrated planning and development assessment framework is the requirement to seek to achieve ecological sustainability. Ecological sustainability is defined under the IP Act as a balance that integrates the protection of ecological processes and natural systems, economic development and the liveability of communities. What this means in practice is that entities undertaking to plan or manage development must integrate and balance a wide range of environmental, social and economic considerations when decisions are made. Figure 8.2 shows the three components that must be considered in seeking to achieve ecological sustainability.

The box on pages 8.4–8.5 provides more information on the planning and development assessment framework. Figure 8.3 shows the regions for which planning frameworks are being prepared.

The environmental monitoring of a human settlement needs to take into account the internal environment of that settlement and its utility in meeting human needs, as well as the settlement's impacts on the external environment through resource use and waste production. To capture the complexity of the human settlements dimension of environmental management, successive Commonwealth state of the environment reports (Newman et al. 1996; Newton et al. 2001) have progressively developed an extended urban metabolism (EUM) model to provide an appropriate conceptual framework.

The model presents human settlements as a combination of **urban systems and processes** that use **resource inputs** and produce outputs of **liveability**, **urban environmental quality** and **waste and emissions** (figure 8.4).

Changes in resource inputs, waste outputs, liveability and environmental quality provide the basis for assessing the performance of human settlements over time. A key area for future improvement is 'closing the loop' so that waste by-products from one process become resource inputs for another.

Resource inputs for urban systems include material things, such as land, water, energy, food, and extractive materials. They also include social and economic inputs, such as people and capital resources.

Urban systems and processes are the individual, community, industrial and government actions and processes that use and transform these resource inputs to produce liveability, urban environmental quality and waste outputs. Urban systems include the laws and regulations that govern human settlements and the physical fabric of cities and towns, such as houses, industries, roads and other infrastructure.

Liveability, or human wellbeing, is a key output of urban systems and is a principal aspect that attracts people to live in urban settlements. Liveability has many aspects, including employment opportunities, housing affordability, accessibility to community services, and health.

Urban environmental quality relates to the natural aspects of the urban environment, such as noise and local air and water quality. These are also important contributors to or detractors from liveability for urban residents.

Waste and emissions are an output of urban systems; they include wastewater, solid waste, air pollution and greenhouse gases. Through recycling, wastewater and solid waste can become an important resource input for urban systems.

Within the conceptual framework of the EUM model and Queensland's integrated planning and development assessment framework, this chapter seeks answers to three basic questions:

- What are matters that affect or are affected by human settlements and how do they impact on the environment?
- What has changed since 1999?
- How have we responded to this change?



Figure 8.2 *Seeking to achieve ecological sustainability*

Queensland's integrated planning and development assessment framework

The *Integrated Planning Act 1997* (IP Act) makes provision for decision makers to work towards ecological sustainability through the pursuit of two broad objectives.

The first objective is managing the process and effects of development, including the growth of human settlements, through an integrated development assessment system (IDAS). IDAS provides an administrative process to manage development. It provides a single, integrated process for making, assessing and deciding on applications for development regulated under different legislation and assessed by multiple agencies. IDAS provides consistency and transparency for the development assessment process.

The second objective is the coordination and integration of planning at the state, regional and local levels. The planning instruments and processes available under the IP Act include state planning policies, state IDAS codes for development assessment, the outputs of regional planning processes under regional planning advisory committees (RPACs), local government planning schemes, and priority infrastructure plans (PIPs).

The term 'integrated planning and development assessment framework' is used to describe the planning instruments and processes under the IP Act and their complex interrelationships with other legislation, plans and regulatory processes, as well as the wide range of stakeholders and participants in the framework as a whole.

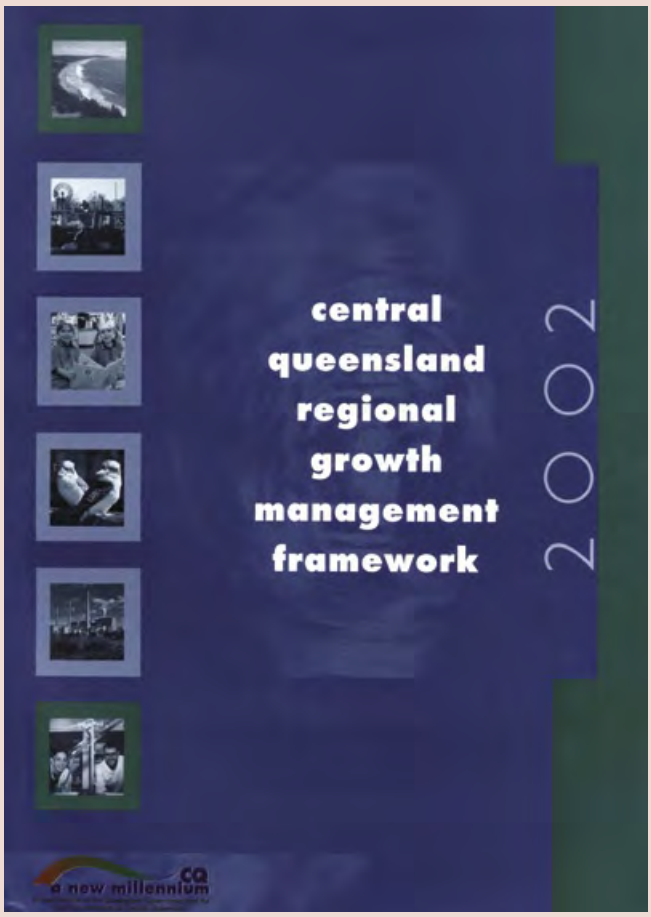
At the *state level*, the framework makes provision for state planning policies (SPPs). These are statutory instruments developed by state agencies on matters of state interest. They are considered in the preparation of planning schemes and in development assessment if not already reflected in the relevant planning scheme. Because the process of preparing SPPs is consultative, it also provides an opportunity for the policies to be coordinated at the state level with the interests of other state agencies. Local government and other stakeholders are consulted during the process of preparing SPPs.

State codes for IDAS are used for development assessment and include criteria for assessing the appropriateness of proposed development in relation to a matter of state interest.

At the *regional level*, RPACs play a pivotal role in the integrated planning and development assessment framework by functioning as a 'nexus' between planning at the state and local levels. This means that RPACs may draw down planning matters from the state level and coordinate and integrate these matters with a wide range of social, economic, infrastructure and environmental matters at the regional level before providing strategic direction to planning at the local level. Such matters include state strategies such as the State Infrastructure Plan and Growing Tourism Strategy, regional initiatives such as integrated regional transport plans, regional coastal management plans and integrated catchment management plans, as well as a wide range of other strategies covering issues such as economic, tourism and community development, developed by both government and non-governmental organisations.

The outputs of RPACs depend on the reason for the planning process and may vary from regional growth management frameworks in high-growth areas such as South East Queensland, Wide Bay and Far North Queensland to strategies to coordinate development across local government boundaries, such as the Townsville-Thuringowa Strategy Plan (Pretorius 2002).

The term 'integrated regional planning frameworks' is used to describe the different outputs of RPACs. These frameworks, developed through a partnership approach (Abbott 2001), provide the overarching strategy for the growth and development of regions, and form the basis for coordinating and integrating land use, transport and other planning. They provide an agreed strategy to resolve competing and sometimes conflicting objectives in the region.



Eight regional planning processes are currently being undertaken in Queensland, including Central Queensland–A New Millennium.
Source: DLGP

Since the commencement of the first regional planning initiative in South East Queensland (SEQ 2001) in 1990, eight integrated regional planning frameworks have been developed. The regional planning areas are shown on figure 8.3. These plans encompass approximately 39% of the land area, 94% of the population and 60% of the local government areas of the state.

Eight regional planning processes are currently being undertaken under regional planning advisory committees. These are South East Queensland 2021; Eastern Downs Regional Land Use Strategy; Wide Bay 2020; Central Queensland—A New Millennium; Whitsunday Hinterland and Mackay 2015; Townsville-Thuringowa Strategy Plan; Far North Queensland 2010; and the Gulf Regional Development Plan. The latest initiative, a three-year review of the SEQ Regional Framework for Growth Management (RFGM) 2000, started in June 2001.

At the *local level*, planning schemes are prepared by local governments, which have a key role to play in the framework by managing growth and change in their areas within the context of ecological sustainability. Under the IP Act, planning schemes must have due regard for state and regional considerations and identify the environmental outcomes sought for the local government area as a whole and for particular localities. They must also manage development through the allocation of land for different uses (including residential growth), identify areas that constrain the use of land due to their environmental values or adverse effects on development, identify the kind of development that requires assessment and, last, specify criteria for assessing the suitability of proposed development.

The IP Act also recognises the importance of infrastructure in well-planned settlements. Planning schemes can facilitate cost-efficient settlement patterns by identifying areas where urban infrastructure can be provided in the most timely and cost-efficient manner. Under recent amendments to the IP Act, planning schemes are required to include priority infrastructure plans (PIPs). These plans must identify the areas required to accommodate 10 to 15 years growth in residential, retail/commercial and industrial urban sectors. PIPs will include details of any future local government infrastructure proposed to meet the needs of growth. Infrastructure defined as development infrastructure under the IP Act and planned under the local government's PIP can be charged for under an infrastructure charges schedule (ICS). The cost of the planned infrastructure must be apportioned between existing and future users in accordance with the fair apportionment principles in the IP Act.

By June 2004, transitional planning schemes prepared under former legislation are to be replaced by planning schemes that comply with the IP Act.

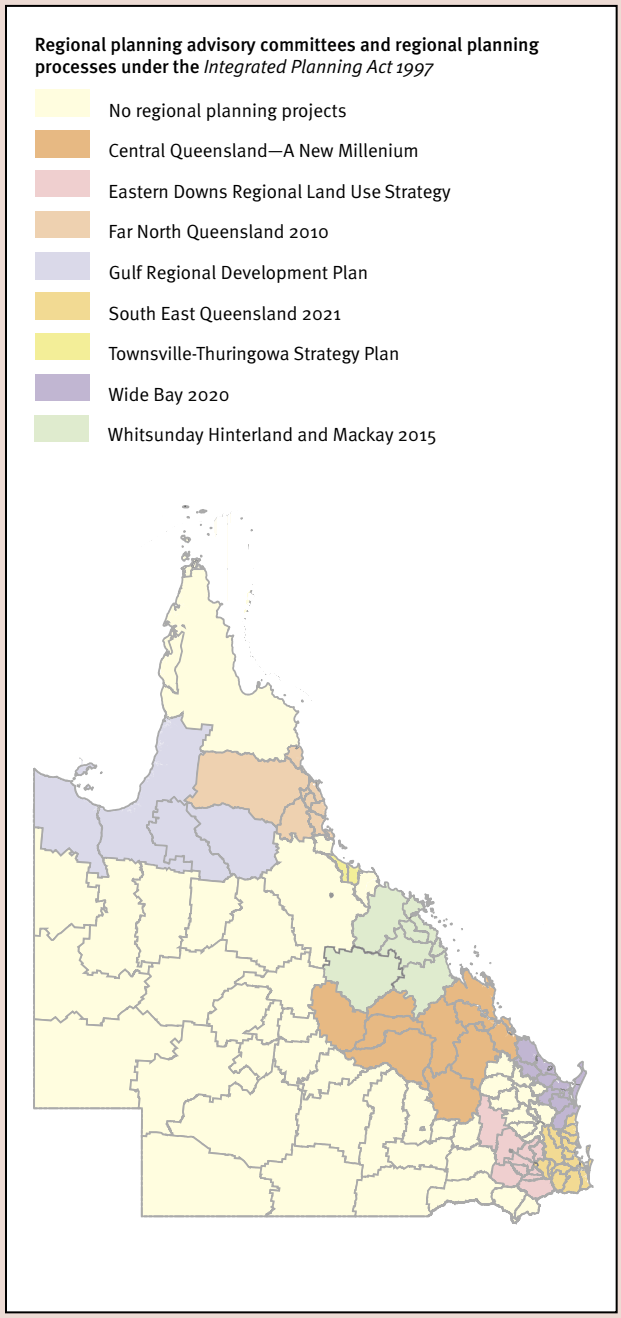


Figure 8.3 *Regional planning processes in Queensland*
Source: DLGP

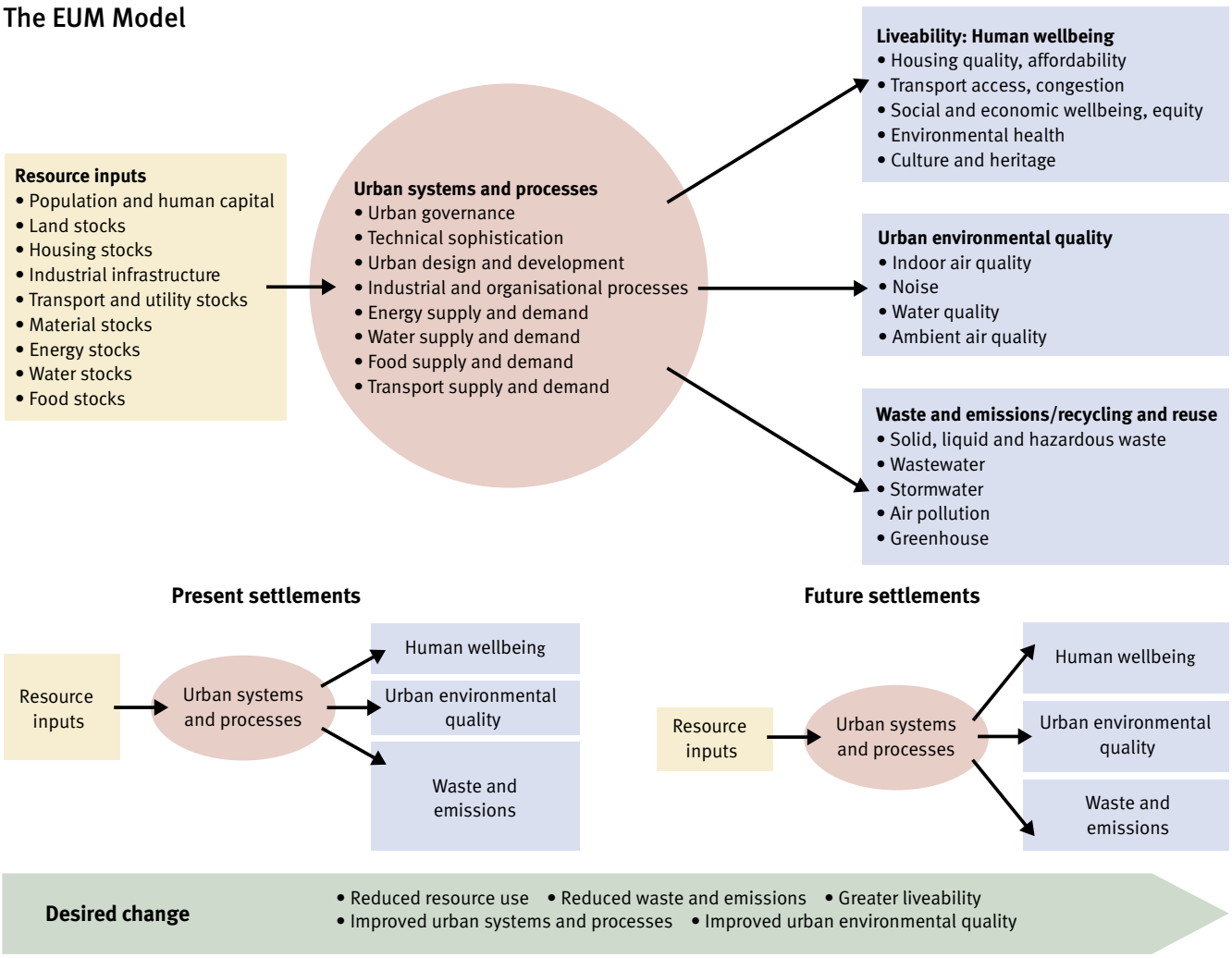


Figure 8.4 *The Extended Urban Metabolism (EUM) model*
Source: Newton 2002

This chapter uses components of the EUM model as a framework for identifying issues and desired directions for change within each section. The discussion generally follows the pressure-condition-response (P-C-R) sequence recommended by ANZECC (2000). Where possible, the indicators used are a continuation of those used in 1999 (EPA 1999b) and in the Commonwealth state of the environment report (Newton et al. 2001). The discussion focuses on changes since 1999, over the 1996–2001 Census period, or over a a 10- or 20-year timeframe to illuminate longer-term trends. Each section begins with a short summary that highlights the key findings.

Conclusion

Because of the complexity of human settlements, the responses of state and local governments to these trends have been both numerous and wide-ranging. A range of instruments and mechanisms, under the IP Act and other legislation, have been developed since 1999. State and local governments have also introduced a number of environmental initiatives, measures and programs, adding to Queensland's capacity to respond to changing circumstances and challenges.

The table on page 8.7 provides a summary of trends in socioeconomic and environmental indicators for human settlements in Queensland since 1999.

It is clear that a number of challenges remain in seeking to manage the impacts of human settlement on the environment. These challenges include managing continuing urban growth in coastal areas; curbing the rising levels of energy consumption; managing private motor vehicle use and congestion levels in urban centres; helping communities, particularly rural communities, adapt to changing economic circumstances; reducing the relative disadvantage of Indigenous people and of some urban areas; and maintaining high levels of liveability as urban densities increase. These challenges will require changes to the form of the built environment, to government policies and funding, and to people's behaviour.

Although progress is being made in managing the process and effect of development through Queensland's integrated planning and development assessment framework, there is still much to do. The IP Act is subject to continuing review and amendment to improve the efficiency and effectiveness of the system. Matters that should receive particular consideration in future are:

- strategic leadership and direction from the state government in the form of legislation and policy;
- the strengthening of planning at the regional level; and
- other measures to assist local governments to better coordinate and integrate state and regional considerations with local matters when they manage development and plan for the future of Queensland's human settlements.

Summary of trends in human settlements indicators since 1999

Indicator	Status*
Population growth and settlement pattern	
Population growth rate	▼ Lower in 1996–2001 but has risen strongly since 2002
Net migration	▼ Similar pattern to population growth rate
Visitor numbers	▲ Steady growth in domestic but a fall in international visitors
Population distribution	Becoming more concentrated in South East Queensland and in major coastal cities
Residential density	▲ Increasing in major urban centres
Integrating planning at the state, regional and local levels	▲ Progress made with systemic reforms and development of planning instruments
Economic activity and employment	
Economic growth	▲ Shifting to tertiary industries
Distribution of economic activity	Becoming more concentrated in South East Queensland
Unemployment	▼ Decreasing with regional variations
Information economy	▲ Increasing with regional variations
Travel and transport	
Distance travelled	▲ Vehicle kilometres travelled increasing
Total fuel consumption	▲
Public transport use	▼ The number of people using public transport is increasing in South East Queensland, but the proportion of the population using it is decreasing
Congestion	▲
Consumption of resources	
Per capita energy use	▲ Increasing at the highest rate in Australia
Per capita water consumption	▼ Variable, possibly declining
Total energy use	▲
Energy sources	Black coal continues to be the main energy source
Total water consumption	▼ Steady
Renewable energy use	▲ Increasing slowly
Waste outputs	
Solid waste per capita	▼
Wastewater per capita	No change apparent
Total solid waste	▼
Total wastewater	▲
Solid waste recycling	▲
Wastewater reuse	▲
Liveability	
Noise complaints	▲
Community attitudes	No time series information available
Life expectancy	▲
Areas of disadvantage	No time series information available
Housing affordability	▼ Sharp decline since January 2002
Changes in community renewal areas	Only limited evaluations done
Urban green space	▲ (Qualitative information only)

*Shows the direction of movement of the indicator from its status in 1999 (EPA 1999b).

Key to trend:
▲ increasing
▼ decreasing

Population and settlement pattern

Summary

Queensland's population grew by 8.9% from 3.34 million in 1996 to 3.63 million in 2001. The rate of growth was slower in 1996–2001 than in the 1991–96 period due to a decline in interstate migration. Since 2001, population growth has accelerated to near record levels, driven by strong overseas and interstate migration. Visitor numbers have grown, particularly domestic visitors, but international visitor numbers have fallen since 11 September 2001.

The distribution of population growth has been uneven; the majority (81.4%) has occurred in the South East Queensland (SEQ) metropolitan region. The state's population is becoming more concentrated in the south-east corner. Steady growth has also occurred in coastal cities, but many inland and western areas have experienced population decline.

Queensland has become more urbanised since 1991. The state's population growth has occurred in urban areas, and the population of rural areas has declined by 7000. The larger urban areas have also grown faster than the smaller towns. The proportion of the population living in cities and towns of more than 100 000 people rose from 49.5% in 1991 to 59.5% in 2001.

While low-density suburbs continue to be the major form of urban development in Queensland, there has been a significant increase since 1991 in the number of attached houses, such as units and apartments. The proportion of new dwellings that are attached is almost 50% in Brisbane City and the Gold Coast, and 40% in Cairns. This has resulted in rising densities in these urban areas. The construction of over 6000 units and high-rise apartments in inner Brisbane since 1991, along with other urban consolidation measures, has produced a population increase of over 11 000 and has revitalised the inner city area.

The nature of this settlement pattern, in terms of the form and density of the built environment, affects the way in which urban populations use resources and produce wastes, as well as the liveability of areas within the towns and cities. Higher urban densities and a more compact urban pattern are generally considered to provide better sustainability outcomes in terms of the EUM model (Newton et al. 2001), because resource inputs (such as land, building materials, water and transport fuels) and waste outputs (such as air pollutants and greenhouse gases) are reduced. In terms of liveability, some aspects may improve, such as public transport accessibility, while others, such as housing affordability and perceived quality of life, may decline.

Economic, social and environmental considerations play a key role in decision making under Queensland's integrated planning and development assessment framework. However, a wide range of decisions made by government agencies under other legislation, policies and programs also affect the pattern of settlement. Development and change associated with the growth of human settlements have, since March 1998, been managed through an integrated planning and development assessment framework established under the IP Act. With this framework, now in its fifth year of implementation, the issue is what progress has been made in managing the effect of development on the environment.

At the *state level*, three new state planning policies (SPPs) have been introduced since 1999 to help manage the effects that aspects of human settlement may have on the environment. At the *regional level*, eight integrated regional planning frameworks seeking to coordinate and integrate a wide range of environmental, economic and social considerations have been progressed. At the *local level*, all the relevant local governments have begun preparing their IP Act-compliant planning schemes. Twelve local governments have adopted IP Act-compliant planning schemes, while others are at various stages of the plan-making process.

An objective of the planning reform under the IP Act was to integrate about 60 separate approval processes for development that relate to the growth of human settlement. Approximately 80% of the original program has now been completed. In addition, a number of state codes and policies for the integrated development assessment system (IDAS) have been introduced. For the environment, the most relevant of these is a state code for IDAS under the *Vegetation Management Act 1999*.

It is not possible at this stage to evaluate the efficiency and effectiveness of the IP Act in facilitating ecological sustainability. It will take many years for the changes instituted by the IP Act to become manifest in settlement patterns, and many local governments are still preparing and implementing their planning schemes.



The Brisbane CBD in 1968 (left) and 2003 (right), showing the growth in high-rise offices and apartments (Photos: left, EPA; right, L. Knight, EPA)

Pressures

Population growth

Queensland's population increased from 3.34 million in 1996 to 3.63 million in 2001. The state's rate of population growth is considerably higher than the growth rate for Australia as a whole. However, the rate of population growth slowed from a high of 12.8% between 1991 and 1996 to 8.9% for the period 1996–2001.

The rate of population growth rose following the 2001 Census, with an increase of 86 200 people in Queensland for the year 2002, the highest increase since 1989.

Population growth or decline is a function of the natural increase in population (births minus deaths) plus or minus migration.

Natural increase in the population depends on fertility rates (that is, the average number of children born to each woman) and life expectancy. Fertility rates declined in Queensland and Australia for many years and this fall is expected to contribute to the long-term decline in the rate of population growth in Queensland (DLGP 2001). The decline in fertility rates, coupled with greater life expectancy, is contributing to an ageing of the population, which has implications for employment opportunities and services required in urban areas.

With the long-term decline in the rate of natural increase, migration is playing a greater role in Queensland's population growth. The slowing of the rate of population growth in Queensland between 1996 and 2001 was largely due to a decline in interstate migration resulting from an improvement in economic conditions in the southern states. This contrasts with the period between 1986 and 1996, when interstate migration was the major contributor to population growth (figure 8.5). The key to the significant population increase in 2002 is the addition of 36 500 interstate migrants and 25 900 overseas migrants.

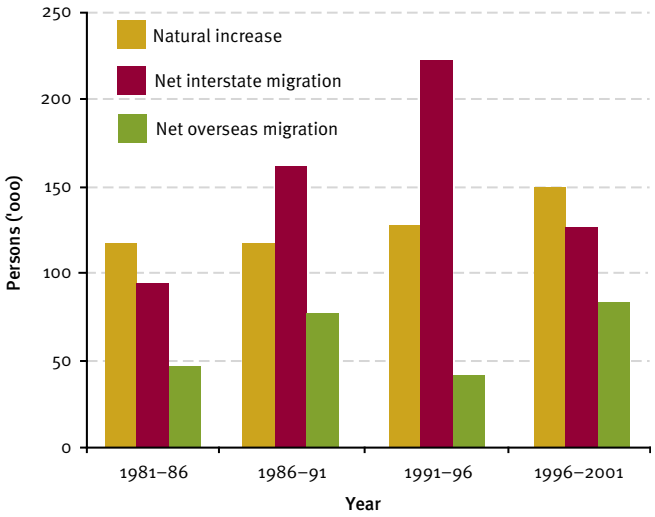


Figure 8.5 *Components of estimated residential population change, Queensland, 1981–2001*
Source: DLGP, from ABS Census figures

Visitor numbers

Queensland is a major tourist destination for domestic and international visitors. Tourist numbers increase the population of many urban coastal areas at certain times of the year. These visitor numbers are, in a sense, hidden because they do not form part of the estimated resident population figures. Nevertheless, high visitor numbers can greatly increase the adverse impacts of human settlements on the natural environment and reduce liveability for residents.

Domestic tourism figures include Queenslanders visiting other parts of the state and interstate visitors. Tourism Queensland introduced a new method of measuring domestic tourism activity in 1998. Consequently, figures are available only for the years from 1999 onwards.

Since 1999, domestic tourism visitor numbers in Queensland have grown by around 0.3% a year. (Figures include both Queenslanders and interstate visitors.) The number of interstate visitors has increased by 3.3% a year (table 8.1). The areas where domestic visitors spent the most time were Brisbane, the Gold Coast and the Sunshine Coast (Qld Treasury 2002b).

Between 1999 and 2003, the number of international visitors to Queensland declined at an average annual rate of 1.9% (table 8.2). In recent years, areas where international visitors spent the most time were Brisbane, the Gold Coast and far north Queensland. The number of nights spent by international visitors in Queensland coastal and outback towns grew, thus increasing economic activity in these areas (Qld Treasury 2002b).



Domestic and international visitors to Queensland increase the environmental impacts of coastal settlements.
(Photo: J. Dunn, DLGP)

Table 8.1 Domestic tourism visitors and visitor nights by origin, 1999 and 2003

Origin	Visitors ('000)			Visitor nights ('000)		
	1999	2003	Average annual growth 1999–2003 (%)	1999	2003	Average annual growth 1999–2003 (%)
Queensland	11 527	11 112	–0.9	39 552	38 146	–0.9
Interstate	4 835	5 468	+3.3	38 532	41 405	+1.9
Total	**16 362**	**16 580**	**+0.3**	**78 083**	**79 551**	**+0.5**

Source: BTR National Visitor Survey

Table 8.2 International tourism visitors and visitor nights, 1999 and 2003

Visitors ('000)			Visitor nights ('000)		
1999	2003	Average annual growth 1999–2003 (%)	1999	2003	Average annual growth 1999–2003 (%)
1 967	1 815	–1.9	24 025	24 894	+0.9

Source: BTR International Visitor Survey

Table 8.3 Estimated resident population and population change, Queensland statistical divisions, 1991, 1996 and 2001

Statistical Division	1991	1996	2001	Absolute change 1991–96	Absolute change 1996–2001	Percentage change 1991–96	Percentage change 1996–2001
Brisbane	1 357 993	1 519 991	1 650 422	+161 998	+130 431	+11.9	+8.6
Moreton	489 615	618 231	724 184	+128 616	+105 960	+26.3	+17.1
Wide Bay-Burnett	195 566	224 285	236 492	+28 719	+12 207	+14.7	+5.4
Darling Downs	194 136	199 920	210 351	+5 784	+10 424	+3.0	+5.2
South West	29 130	26 449	27 002	–2 681	+553	–9.2	+2.1
Fitzroy	168 368	178 028	181 747	+9 660	+3 719	+5.7	+2.1
Central West	13 382	12 570	12 497	–812	–73	–6.1	–0.6
Mackay	123 793	133 466	137 539	+9 673	+4 073	+7.8	+3.1
Northern	169 089	179 037	190 266	+9 948	+11 229	+5.9	+6.3
Far North	181 399	210 766	224 163	+29 367	+11 823	+16.2	+5.6
North West	38 221	35 947	34 283	–2 274	–90	–5.9	–0.3
Queensland	**2 960 692**	**3 338 690**	**3 628 946**	**+377 998**	**+290 256**	**+12.8**	**+8.7**
Australia	**17 284 036**	**18 310 714**	**19 413 240**	**+1 026 678**	**+1 102 526**	**+5.9**	**+6.0**

Source: ABS 2003a

Table 8.4 Queensland's urban and rural population in 1991 and 2001

Areas	1991	Percentage	2001	Percentage	Change 1991–2001
Urban centres	2 383 000	80	3 051 000	83.5	+668 000
Localities	94 000	3	110 000	3.0	+16 000
Rural areas	501 000	17	494 000	13.5	–7 000
Total	**2 978 000**	**100**	**3 655 000**	**100.0**	**677 000**

Source: DLGP, from ABS Census figures

Condition and trends

Regional population distribution

The spatial distribution of population and other socioeconomic data are classified according to the Australian Standard Geographic Classification, which divides states into Statistical Divisions (SDs) and Statistical Local Areas (SLAs). Local government area boundaries are concurrent with those of one or more SLAs. Figure 8.6 shows the estimated resident population of Queensland's eleven SDs as a proportion of the state's population.

In 2001, South East Queensland (Brisbane and Moreton SDs) accommodated 2.38 million people, or 65.4% of the state's population. Over the period 1996–2001, 81.4% of the state's population growth occurred in South East Queensland. The state's population is becoming more concentrated in the south-east corner.

Between 1996 and 2001, the region with the fastest rate of growth was the Moreton SD, which consists of the Gold Coast and Sunshine Coast urban areas and rural areas in South East Queensland. Moreton was the only SD in the state where the population growth rate was higher than the state's population growth rate (figure 8.6). Steady population growth occurred in the Brisbane, Wide Bay-Burnett, Darling Downs, Northern and Far North SDs. However, the rate of population growth in

Moreton, Wide Bay-Burnett and Far North had slowed considerably in 1996–2001, compared to 1991–96. In contrast, the rate of population decline in two western SDs (Central West and North West) slowed in 1996–2001 and the population in South West increased (table 8.3).

Growth and distribution of urban areas

An urban area is a population cluster of more than 200 people and includes what the ABS defines as urban centres and localities. An urban centre is a population cluster of 1000 or more people, while a locality is a population cluster of between 200 and 999 people. In 2001, 86.5% of Queenslanders lived in urban areas, a significant increase from 83% in 1991 (table 8.4).

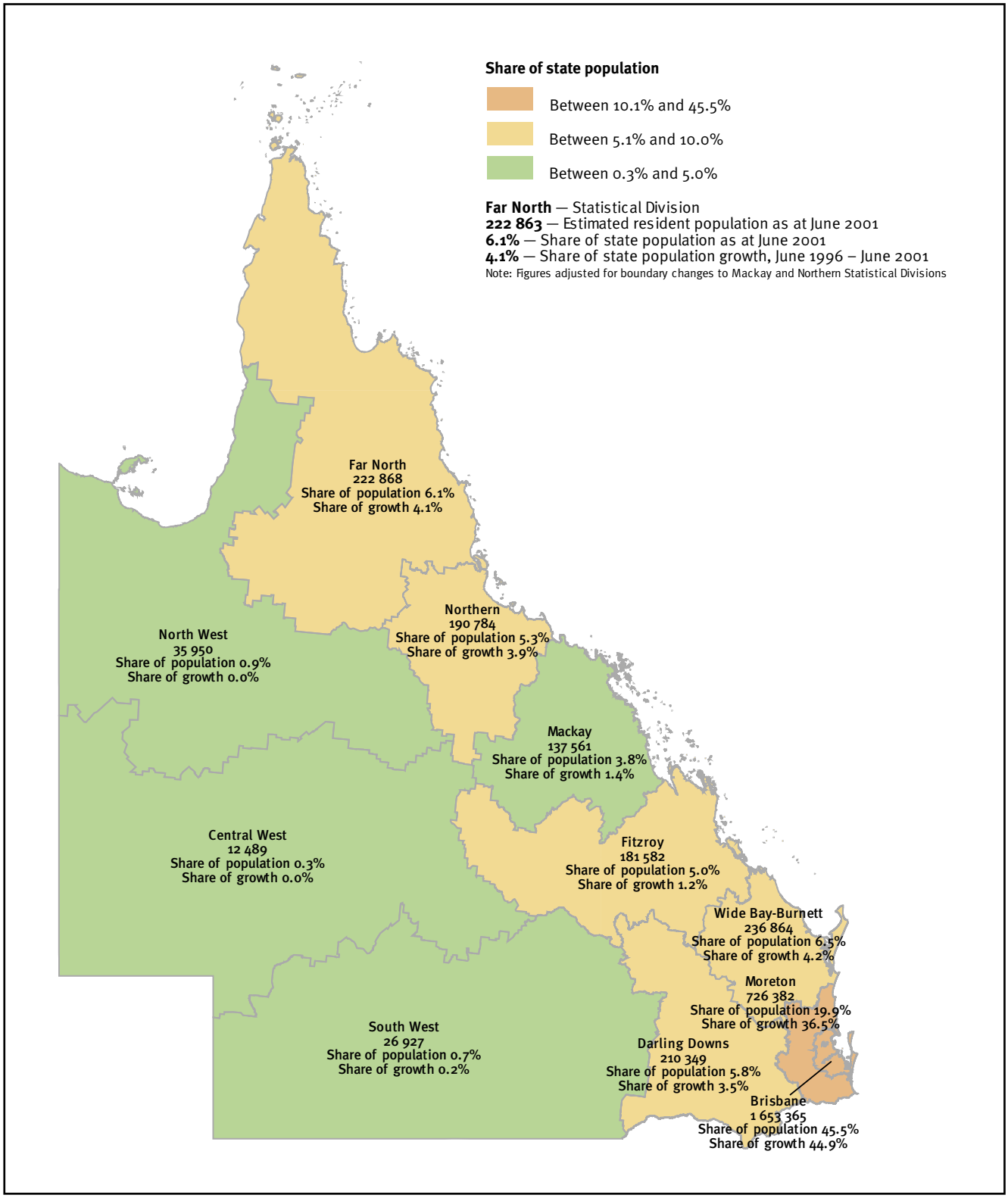


Figure 8.6 *Population, share of state population and share of growth by Statistical Division, Queensland, 1996–2001*
Source: DLGP, from ABS figures

Table 8.5 Number and size of Queensland's urban areas in 1991 and 2001

Size of urban areas	Number of population centres		Qld population count		Share of Qld population count (%)	
	1991	2001	1991	2001	1991	2001
500 000 and over	1	1	1 145 537	1 508 161	38.5	41.3
100 000–499 999	2	3	327 171	665 968	11.0	18.2
10 000–99 999	20	16	528 599	541 061	17.8	14.8
1 000–9 999	134	122	381 366	335 363	12.8	9.2
200–999	180	214	94 480	110 158	3.2	3.0
Total	**337**	**356**	**2 477 153**	**3 160 711**	**83.3**	**86.5**

Source: DLGP, from ABS Census figures

Table 8.6 Number of dwellings by type, Queensland, 1991 and 2001

Dwelling type	1991	2001	Absolute change 1991–2001	Percentage change 1991–2001
Detached dwellings	812 215	1 045 137	+232 922	+28.7
Attached dwellings	154 448	256 403	+101 955	+66.0
Total dwellings	**966 663**	**1 301 540**	**+334 877**	**+34.6**

Source: ABS

Table 8.7 Number of dwellings by type in selected LGAs, 1991 and 2001

LGA and dwelling type	1991	2001	Absolute change 1991–2001	Percentage change 1991–2001
Brisbane City				
Detached	217 071	254 389	+37 318	+17.2
Attached	49 041	81 152	+32 111	+65.5
Total dwellings	**266 112**	**335 541**	**+69 429**	**+26.1**
Gold Coast				
Detached	68 309	100 208	+31 899	+46.7
Attached	36 778	65 268	+28 490	+77.5
Total dwellings	**105 087**	**165 476**	**+60 389**	**+57.5**
Cairns City				
Detached	24 307	31 210	+6 903	+28.4
Attached	8 646	13 144	+4 498	+52.0
Total dwellings	**32 953**	**44 354**	**+11 401**	**+34.6**
Toowoomba				
Detached	22 449	26 687	+4 238	+18.9
Attached	4 840	5 399	+559	+11.5
Total dwellings	**27 289**	**32 086**	**+4 797**	**+17.6**

Source: ABS

Table 8.8 Changes in urban densities in selected LGAs, 1995–2001

LGA	1995 Persons/km²	2001 Persons/km²	Percentage change 1995–2001
Brisbane City	1826	1924	+5.4
Gold Coast	1036	1208	+16.6
Cairns City	1242	1256	+1.1

Source: DLGP

Figure 8.1 shows the distribution and size of urban areas in Queensland in 2001, and the major roads linking them. Apart from Mount Isa, Emerald, Toowoomba and Warwick, all the urban areas with populations greater than 10 000 are located on or near the coast. The larger urban areas are generally growing faster than the smaller areas (table 8.5). In 1991 the proportion of the population living in cities and towns of more than 100 000 people was 49.5%. By 2001 this proportion had increased to 59.5%.

At the local government area (LGA) level, the fastest growing LGAs, in absolute population numbers, between 1991 and 2001 were the coastal areas, including Cairns, Townsville, Mackay, Bundaberg and Hervey Bay, and the coastal South East Queensland LGAs between Noosa and the Gold Coast (figure 8.7). The impacts of this growth on coastal ecosystems are discussed in Chapter 6, 'The coastal zone'. In the inland and western areas of Queensland, the picture was more varied; most LGAs declined in population, but growth occurred in and around Toowoomba and at Emerald and Cloncurry.

Housing types and urban densities

Traditionally, urban residential areas in Queensland have consisted of low-density detached dwellings on 'quarter-acre' blocks (approximately 1000 m²). Over the past decade, the proportion of new dwellings that are 'attached'—townhouses, flats, units and high-rise apartments—has increased. In 1991, only 16.0% of dwellings in Queensland were attached. Over the period 1991–2001, 30.4% of new dwellings constructed were attached. Consequently, the proportion of attached dwelling stock rose to 19.7% by 2001 (table 8.6).

In some areas, such as Brisbane and the coastal tourist centres, the proportion of new dwellings that are attached is significantly higher than the state average. In Brisbane City, between 1991 and 2001, the proportion rose by 65.5%. For the Gold Coast, the figure was 77.5% and for Cairns City it was 52.0%. In other urban centres, such as Toowoomba, the proportion of new attached dwellings remains low; between 1991 and 2001, it rose by only 11.5% (table 8.7).

Overall urban densities have proved difficult to define and measure. One of the main reasons for this is that the boundaries of the built-up urban area are continually expanding. Recent performance monitoring work in South East Queensland defined a broad population density based on the estimated resident population divided by the area of lots less than five hectares in area (RCC 2002). The benefit of this measure is that it captures not only attached dwellings in inner city areas, but also low-density development, including rural residential, on the urban fringe. On this basis, urban densities in South East Queensland increased by 5.1% between 1995 and 2001. The likely reasons for the increase are the increase in number of attached dwellings in new and existing urban areas, the development of vacant and difficult lots, and a decline in the creation of large rural residential lots (RCC 2002). Changes in urban densities have been calculated for some LGAs (table 8.8). These figures confirm that densities are rising in areas with growing proportions of new attached dwellings.

Higher urban densities and a more compact urban pattern are generally considered to provide better environmental outcomes in terms of the EUM model (Newton et al. 2001). This is because resource inputs (such as land, building materials, water use and transport fuels) and waste outputs (such as air pollution) are reduced. In terms of liveability, some aspects may be improved as reurbanisation has the potential to provide healthier environments where there is less driving, more walking and greater use of public transport (Frumkin 2002).

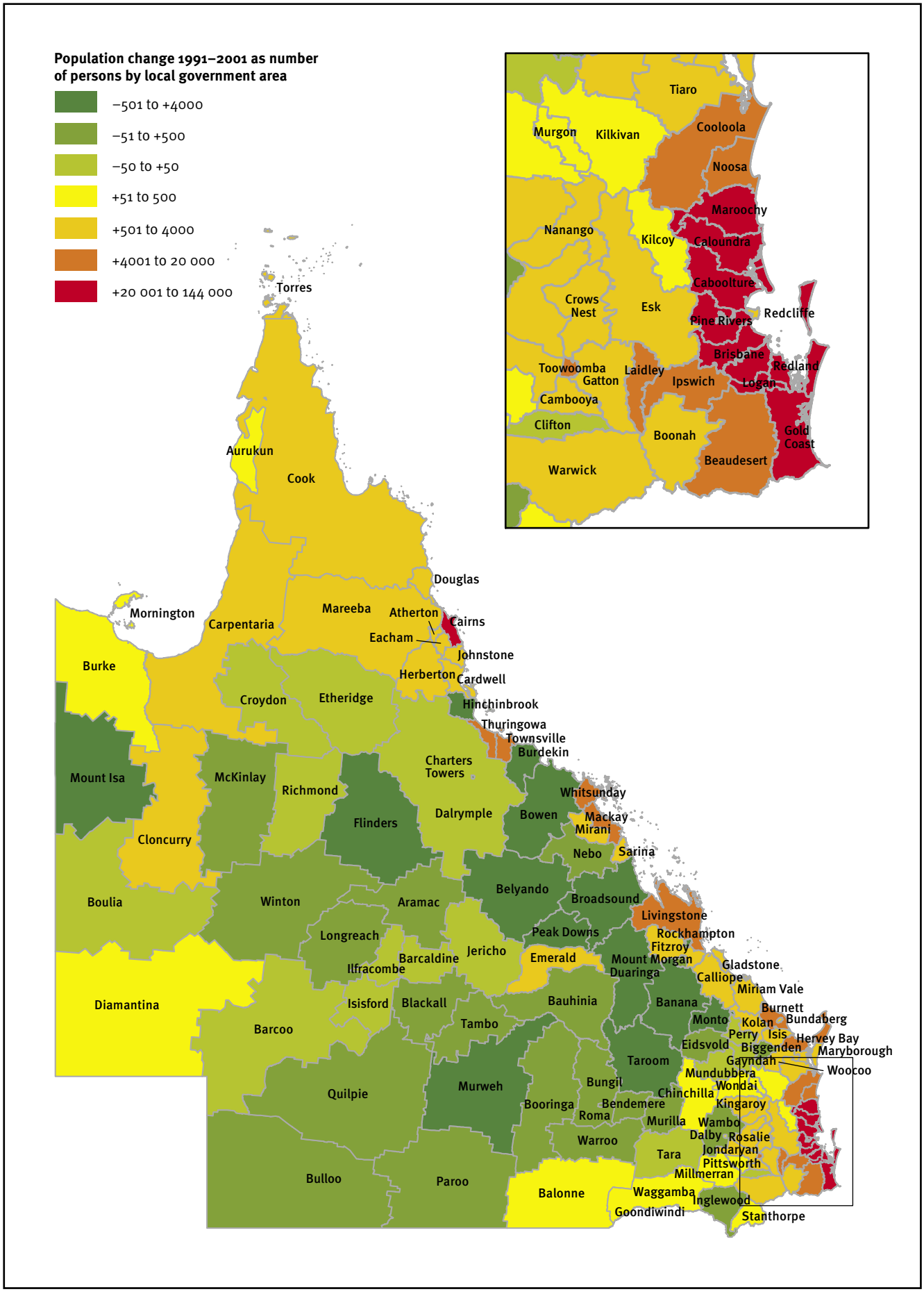


Figure 8.7 *Absolute population growth by local government area, Queensland, 1991–2001*
Source: DLGP



Although houses are still the main form of urban development, the number of unit and apartment developments has increased in Brisbane and in coastal cities. (Photo: L. Knight, EPA)

Responses

Managing development and change

In Queensland, an integrated planning and development assessment framework established under the IP Act plays a key role in managing population growth and its economic, environmental and social impacts, including matters that affect or are affected by human settlement. This framework and the way in which it seeks to manage development and change are discussed in more detail on pages 8.4–8.5.

Queensland's integrated planning and development assessment framework makes provision for a number of 'planning tools' to coordinate and integrate planning at the state, regional and local levels. The most important of these are state planning policies, regional planning advisory committees and local government planning schemes.

Three state planning policies (SPPs) have been developed since 1999. The first, *SPP 1/02: Development in the Vicinity of Certain Airports and Aviation Facilities*, aims to protect airports and associated aviation facilities from encroachment by incompatible developments. *SPP 2/02: Planning and Managing Development involving Acid Sulfate Soils* seeks to ensure that development is planned and managed to avoid the release of potentially harmful contaminants into the environment. The most recent, effective from 1 September 2003, is *SPP 1/03: Mitigating the Adverse Impacts of Flood, Bushfire and Landslide*. It is aimed at minimising the potential adverse impacts of flood, bushfire and landslide on people, property, economic activity and the environment. In addition, the State Coastal Management Plan developed under the *Coastal Protection and Management Act 1995* in 2001 has the status of an SPP. Two SPPs prepared before the introduction of the IP Act were *SPP 1/92: Development and Conservation of Agricultural Land* and *SPP 1/97: Conservation of Koalas in the Koala Coast*.

A number of integrated regional planning frameworks have also been developed since 1999. The Far North Queensland Regional Plan was endorsed in March 1999, followed by the Townsville-Thuringowa Strategy Plan in 2000 and the Gulf Regional Development Plan in 2001. The latest, Central Queensland—A New Millennium, was endorsed by Cabinet in June 2002. The WHAM 2015 Regional Plan for the Whitsunday Hinterland and Mackay region should be finalised in 2004. In 2001 a three-year review of the regional plan for South East Queensland was initiated under the title *SEQ 2021: A Sustainable Future*.

At the local level, local government planning schemes are the primary tool for managing human settlements. Unlike the regional planning outputs, which are advisory, planning schemes are statutory instruments to manage development within the area of Queensland's local governments. The IP Act requires local governments to seek to achieve ecological sustainability when they prepare their planning schemes. In doing so, they must coordinate and integrate the relevant environmental, economic and social considerations, including state planning policies and the recommendations of regional planning advisory committees, when they develop their planning scheme strategies. These planning scheme strategies give direction for the formulation of desired environmental outcomes. The desired environmental outcomes are, in turn, implemented through a wide range of planning scheme measures such as allocating land for specific land uses, including conservation, and the intensification or heritage protection of designated residential precincts.

The IP Act also recognises the importance of infrastructure in well-planned human settlements. IP Act planning schemes can facilitate cost-efficient settlement patterns by identifying areas where urban infrastructure can be provided in the most timely and cost-efficient manner. Recent amendments to the IP Act strengthen the relationship between land use planning and infrastructure planning by requiring all planning schemes to include a priority infrastructure plan (PIP).

All relevant local governments have begun preparing their IP Act planning schemes. Thirteen local governments have adopted IP Act planning schemes. Other local governments are required to have IP Act-compliant planning schemes by June 2004.

Planning schemes not only coordinate and integrate planning at the local level, but also are vehicles for managing the process of development. This is achieved through Queensland's integrated development assessment system (IDAS). IDAS provides for a wide range of regulatory approvals under various statutes to be integrated in a single administrative process.

When the planning reforms under the IP Act commenced on 31 March 1998, the objective was to integrate about 60 separate approval processes that had existed under the previous system. Approximately 80% of the original program has now been completed. With the amendments proposed to commence in the foreseeable future, it is estimated that approximately 85–90% of all development-related approvals in Queensland will be given through IDAS.

A number of state codes and policies for IDAS have also been introduced under legislation since 1999. For the environment, the most relevant of these is the State Policy for Vegetation Management on Freehold Land established under section 10 of the *Vegetation Management Act 1999*. The Act also makes provision for regional vegetation management plans to be codes for IDAS. Other codes deal with development applications for building work, licensed brothels and self-assessable water-related developments.

Approximately 50 000 development applications (excluding building applications) have been processed annually through the development assessment system since 1998. Over the same period, approximately 400 appeals, or only 1% of all local government development decisions, were lodged annually with the Planning and Environment Court. However, as with the implementation of any wide-ranging planning reform, particularly reform that deals with the complexities of managing development, the IP Act is subject to continuing review and amendment to improve the efficiency and effectiveness of the system.

The Department of Public Works has produced a set of guidelines that can assist local governments, developers and home owners in working towards ecological sustainability.

Case study: Protecting the Koala Coast

The Koala Coast includes parts of the local government areas of Brisbane City, Logan City and Redland Shire, and is a nationally significant koala habitat. This habitat is under increasing threat from South East Queensland's rapid population growth and the resultant increase in human settlement. In 1997 the Queensland Government adopted SPP 1/97: Conservation of Koalas in the Koala Coast in order to protect the area from inappropriate development. Among other measures, the SPP identifies a Koala Conservation Area within which development that may have detrimental long-term impacts on koalas should generally be excluded. It also gives clear direction for the implementation of the SPP through local government planning schemes.

The South East Queensland Regional Framework for Growth Management (RFGM) now designates the Conservation Area as the Koala Coast Core Area, and supports the objectives of SPP 1/97 through a range of objectives, principles and actions.

Brisbane City Council is the first of the Koala Coast councils to have adopted an IP Act planning scheme. The Brisbane City Plan clearly identifies the Koala Conservation Area in its 'Green Space System Values' and 'Green Space Areas'. This strategic intent is carried forward into a number of desired environmental outcomes and the koala habitat is designated as a conservation area or parkland area with corresponding levels of assessment. In particular, all development within the conservation area is made impact assessable, with reconfiguration of a lot (subdivision) and most changes in land uses deemed to be generally inappropriate development.



Koala (Photo: EPA)

Case study: Reurbanisation of Inner Brisbane

The predominant form of urban development in Australian cities over the past 50 years has been detached housing associated with the outward growth of low-density suburbs. While this process continues to absorb most urban growth, over the past 20 years there has been an increasing movement of middle class people back into inner-city areas. This process has been termed 'reurbanisation' (Stimson et al. 2001). In Brisbane, this process began in the 1980s with the gentrification of old working class suburbs such as Paddington, was given impetus in the 1990s by government projects such as Southbank and the New Farm urban renewal area, and has recently brought a proliferation of unit and high-rise apartment construction in and adjacent to the CBD.

The reasons and socioeconomic processes behind this revitalisation of inner-city areas are complex. One possible explanation is that people are choosing inner-city residences to be close to employment opportunities in the developing CBD services and information economy. Another explanation relates to changing lifestyles and preferences and people wanting to be close to restaurants and galleries—the so-called 'café society' (Stimson et al. 2001).

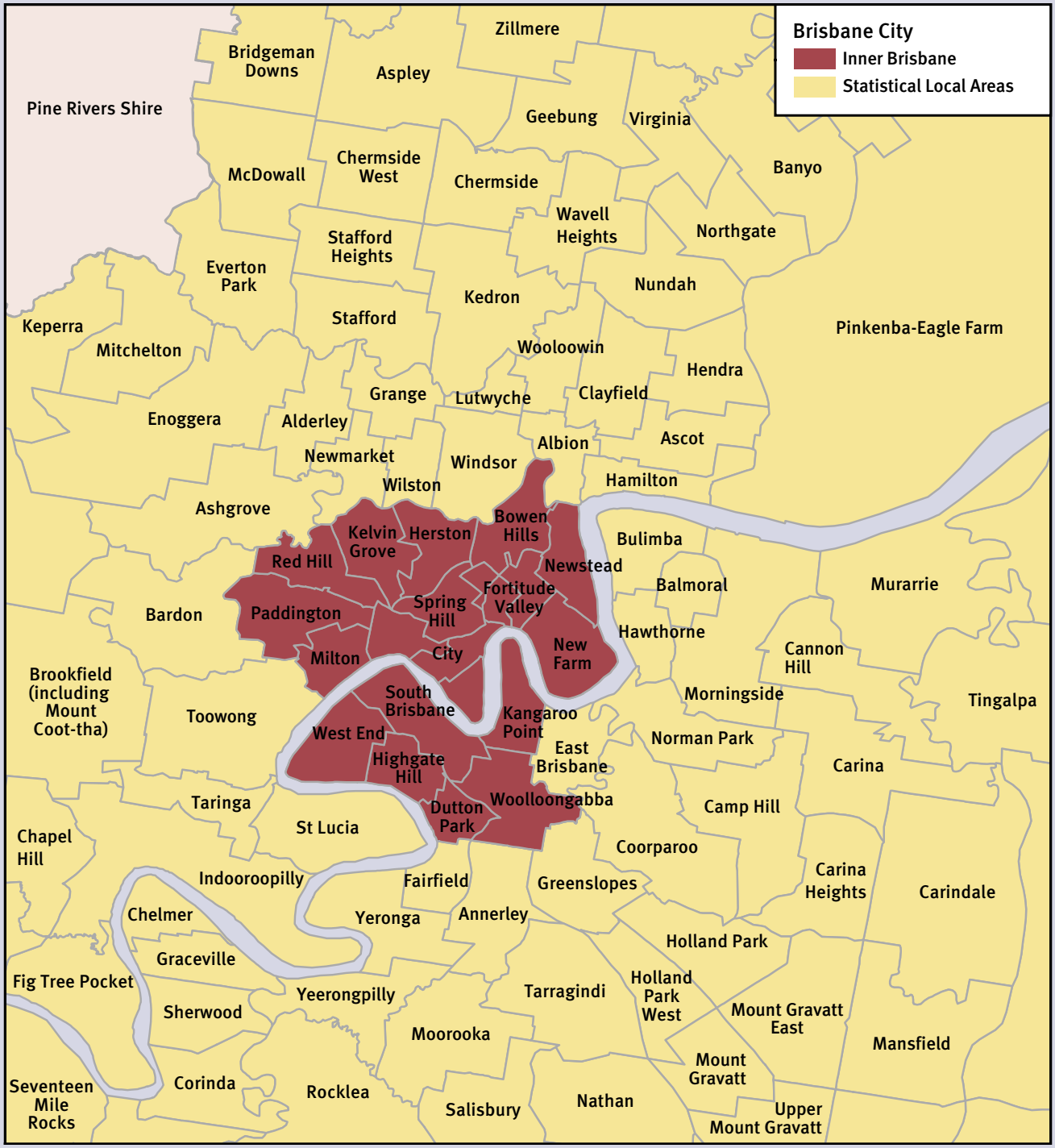


Figure 8.8 *Inner Brisbane and surrounding Statistical Local Areas*
Source: DLGP



People living in apartments on the Brisbane River have access to employment, ferries, public galleries and entertainment venues in the CBD. (Photo: L. Knight, EPA)

Inner Brisbane, as defined by Brisbane City Council, is shown in red on figure 8.8. It comprises the CBD and 16 suburbs, including New Farm, Fortitude Valley, Spring Hill, Milton, Kangaroo Point and West End. In 1971, these areas housed over 80 000 people; by 1986, the number had fallen to around 60 000. Inner Brisbane began to grow again in the late 1980s as tertiary students, young workers, 'empty nesters' and older retirees moved into the area. Its population reached 79 094 in 2001 and included over 9000 tertiary students (DLGP 2002).

The appearance of many parts of Inner Brisbane has changed dramatically because of changes in housing types. Since 1991, over 7000 new dwellings have been constructed. Over 6000 of these new dwellings have been flats, units and apartments, and the majority (72%) have been in buildings of four storeys or more. Since 1991 the number of detached houses in Inner Brisbane has declined by over 100.

High-density inner-city residential development accords with the desired regional outcomes in the South East Queensland Regional Framework for Growth Management (RFGM) 2000. It has a number of environmental benefits: reductions in travel and air pollution result from people living close to their workplaces, and the absence of large gardens means reduced water use. Some of the negative consequences are rising house prices and rents and the displacement of poorer, working class people from inner-city areas (Stimson et al. 2001).

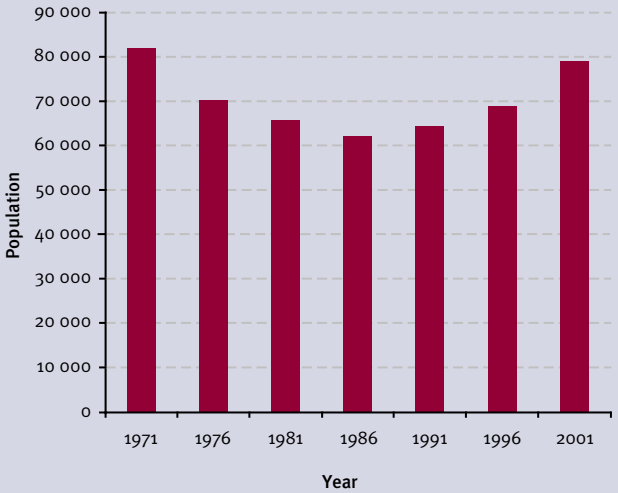


Figure 8.9 *Population of Inner Brisbane, 1971–2001*
Source: ABS Census counts

Economic activity and employment

Summary

The Queensland economy has grown strongly over the past decade at 4.7% a year (Qld Treasury 2002a). Economic growth in the period 1996–2001 was slower than in the period 1991–96, however. Increased economic activity and employment are significant drivers of growth in urban settlements. In line with Australia as a whole, the Queensland economy has changed over the past few decades, moving away from primary and manufacturing industries to a growth in tertiary service industries, such as education, tourism and personal services. Within the tertiary sector, there has been a growing information services sector.

Economic activity is concentrated in the greater metropolitan region of South East Queensland. Many coastal cities and towns are experiencing rapid population growth and rising socioeconomic status (with consequent impacts on the environment), while some inland towns are experiencing population and socioeconomic decline. Small towns of fewer than 10 000 people are generally struggling to maintain their levels of economic activity.

Queensland's response to these trends has been to work towards strengthening the state's economy by adopting the 'Smart State' initiative. This initiative is a package of measures geared at diversifying the state's economy and making it more competitive in the global market. The state has also adopted a regional approach to economic development through the Department of State Development's network of regional business centres.

There are strong interrelationships among the growth and distribution of population, human settlements and the Queensland economy. Economic activity is a driver of growth in urban settlements and a key component of urban systems and processes. However, it also affects the consumption of resources, waste outputs and the liveability of urban areas.

Economic considerations must be balanced and integrated with social and environmental considerations in decisions made under Queensland's integrated planning and development assessment framework. The State Infrastructure Plan developed by the Department of State Development identifies, prioritises and coordinates the provision of critical infrastructure to support economic development in the regions. The economic development strategies of integrated regional planning frameworks developed under regional planning advisory committees draw on the plan. These regional planning frameworks, in turn, are used to inform local planning decisions (local governments are required to coordinate and integrate the recommendations of regional planning advisory committees regarding regional economic development when they prepare their planning schemes).

Pressures

Overall economic growth

Over the period 1991–92 to 2001–02, Queensland's gross state product grew by an average of 4.7% a year. This is higher than the growth of 3.4% a year recorded for the rest of Australia (Qld Treasury 2002a). The economy also grew faster than the population, increasing by an average of 2.1% a year between 1991 and 2001. In terms of employment, the state economy grew from 1 222 060 employed persons in 1991 to 1 568 864 in 2001. In the period 1996–2001, the rate of growth in the state economy was slower than in 1991–96 (table 8.9).

In line with other developed societies and Australia as a whole, the Queensland economy has been changing over the past few decades, moving away from primary industries to growth in tertiary service industries, such as education, tourism, business and personal services. The participation rates of women have increased, as has the proportion of part-time jobs (ABS 2002b).

Table 8.9 Employed persons, Queensland, 1991, 1996 and 2001

1991	1996	2001	Absolute change 1991–96	Absolute change 1996–2001	Percentage change 1991–96	Percentage change 1996–2001
1 222 060	1 420 668	1 568 864	+198 608	+148 196	+16.3	+10.4

Sources: ABS and DLGP

Table 8.10 Employed persons by industry, Queensland, 1996–2001

Industry	1996	2001	Absolute change 1996–2001	Percentage change 1996–2001
Agriculture, forestry, fishing and mining	96 149	95 818	−331	−0.3
Manufacturing	149 271	167 380	+18 109	+12.1
Electricity, gas, water supply	10 158	12 359	+2 201	+21.7
Construction	102 128	111 209	+9 081	+8.9
Wholesale and retail trade	279 908	319 615	+39 707	+14.2
Accommodation and restaurants	77 700	88 381	+10 681	+13.7
Transport and storage	69 594	77 587	+7 993	+11.5
Communication, finance, business services	198 394	221 442	+23 048	+11.6
Government and defence	72 008	75 048	+3 040	+4.2
Education, health, cultural and personal services	318 796	364 928	+46 132	+14.5
Non-classified or not stated	46 562	35 379	−11 183	−24.0
Total	**1 420 668**	**1 569 146**	**+148 478**	**+10.5**

Sources: ABS and DLGP

Over the years 1996–2001, the number of people employed in Queensland's agriculture and mining sector declined. The number of people employed in manufacturing grew steadily and the proportion employed in manufacturing actually increased. The proportions of people employed in the accommodation and restaurant, communication and business services, and education and personal services sectors all grew over this period (table 8.10). The growth in these sectors is linked to domestic and international tourism discussed previously (tables 8.1 and 8.2). Although it is only a small sector, employment in the electricity, gas and water supply industry also grew steadily over the period, reflecting the rising demand for electricity in Queensland.

Analysts have noted the emergence of a growing information services sector within the tertiary sector of the Australian economy. Nationally, the proportion of employment in 'knowledge-related' occupations rose from 31% in 1991 to 38% in 2001 (ABS 2002b). The implications for urban settlements of new information technologies, such as the convergence of telecommunications and computing, have been a matter of some conjecture. While these technologies assist people working from home and enable small towns to link into the wider information economy, their overall effect appears to have been to hasten the process of urbanisation and to strengthen metropolitan regions that have better information capital and infrastructure (Moss 2000).

Condition and trends

Distribution of economic activity

Recent figures for gross regional product are not available across Queensland, but the figures for employed persons from the Census give an indication of the regional distribution of economic activity. The fastest growing region is South East Queensland; between 1991 and 2001 the number of employed persons grew by 47.1%. The state's economy, like its population, is becoming more concentrated in the south-east corner. The Wide Bay, Mackay and Far North regions grew rapidly in the first part of the 1990s but slowed down in the last five years of the decade. Other regions grew more rapidly in the second half of the 1990s; these included South West and Central West, which had experienced a decline in employed persons between 1991 and 1996 (table 8.11).

Economic activity, particularly the location of jobs, affects the nature and growth of urban centres. Mining activity may stimulate growth in remote inland towns and most tourism activity is located in coastal areas. Growth in service industries affects larger towns and cities, particularly the metropolitan area of South East Queensland. The spatial relationship between employment location and population location is also important. If there is a considerable mismatch, as there is in South East Queensland (RCC 2000), it will increase commuting distances and congestion while reducing liveability. The nature of economic activities and the industries in an area are a key part of the urban system in the EUM model. They affect the consumption of resources, the waste outputs produced and the liveability of the urban area, particularly in terms of employment opportunities. A tourist and services centre such as Cairns has impacts and characteristics very different from those of a heavy manufacturing centre such as Gladstone. Sustainability indicators developed for Gladstone show how it is performing across a range of environmental, economic and social factors (GRSG 2001).

Globalisation and economic restructuring over the past decade have affected the prospects and socioeconomic status of towns and urban areas across Queensland. Stimson and Baum (2001) have analysed the patterns of population and economic growth and decline in Queensland LGAs outside South East Queensland. They have noted that many coastal cities and towns are experiencing rapid population growth and rising socioeconomic status, whereas many inland LGAs, especially small ones, are experiencing population and socioeconomic decline. The patterns are uneven and complex, however (figure 8.10). Some LGAs, mainly in southern coastal Queensland, are experiencing above-average population growth and declining socioeconomic status because their growth is based on retirees and other welfare-dependent groups. Other LGAs with a solid services or extractive industry role have below-average growth and above-average socioeconomic status.

Baum et al. (1999) have analysed these patterns of community opportunity and vulnerability for Australia and Queensland for towns of different sizes and with different economic bases. For the larger regional cities and towns (over 10 000 people), they identified places in opportunity clusters, including Cairns (tourism), Mount Isa (mining) and Toowoomba (services), and others in vulnerable clusters including Hervey Bay

Table 8.11 Employed persons, Queensland Statistical Divisions, 1991, 1996 and 2001

Statistical Division	1991	1996	2001	Absolute change 1991–96	Absolute change 1996–2001	Percentage change 1991–96	Percentage change 1996–2001
Brisbane	573 078	664 139	739 838	+91 061	+75 699	+15.9	+11.4
Moreton	191 247	246 316	293 369	+55 069	+47 053	+28.8	+19.1
Wide Bay-Burnett	67 697	78 067	81 981	+10 370	+3 914	+15.3	+5.0
Darling Downs	75 040	80 235	88 152	+5 195	+7 917	+6.9	+9.9
South West	13 166	12 551	13 585	–615	+1 034	–4.7	+8.2
Fitzroy	69 588	75 703	78 093	+6 115	+2 390	+8.8	+3.2
Central West	6 746	6 102	6 864	–644	+762	–9.5	+12.5
Mackay	53 472	61 305	62 288	+7 833	+983	+14.6	+1.6
Northern	71 854	78 082	84 784	+6 228	+6 702	+8.7	+8.6
Far North	81 493	98 553	100 930	+17 060	+2 377	+20.9	+2.4
North West	17 945	18 178	18 347	+233	+169	+1.3	+0.9
Queensland	**1 221 326**	**1 419 231**	**1 568 231**	**+197 905**	**+149 000**	**+16.2**	**+10.5**

Source: ABS

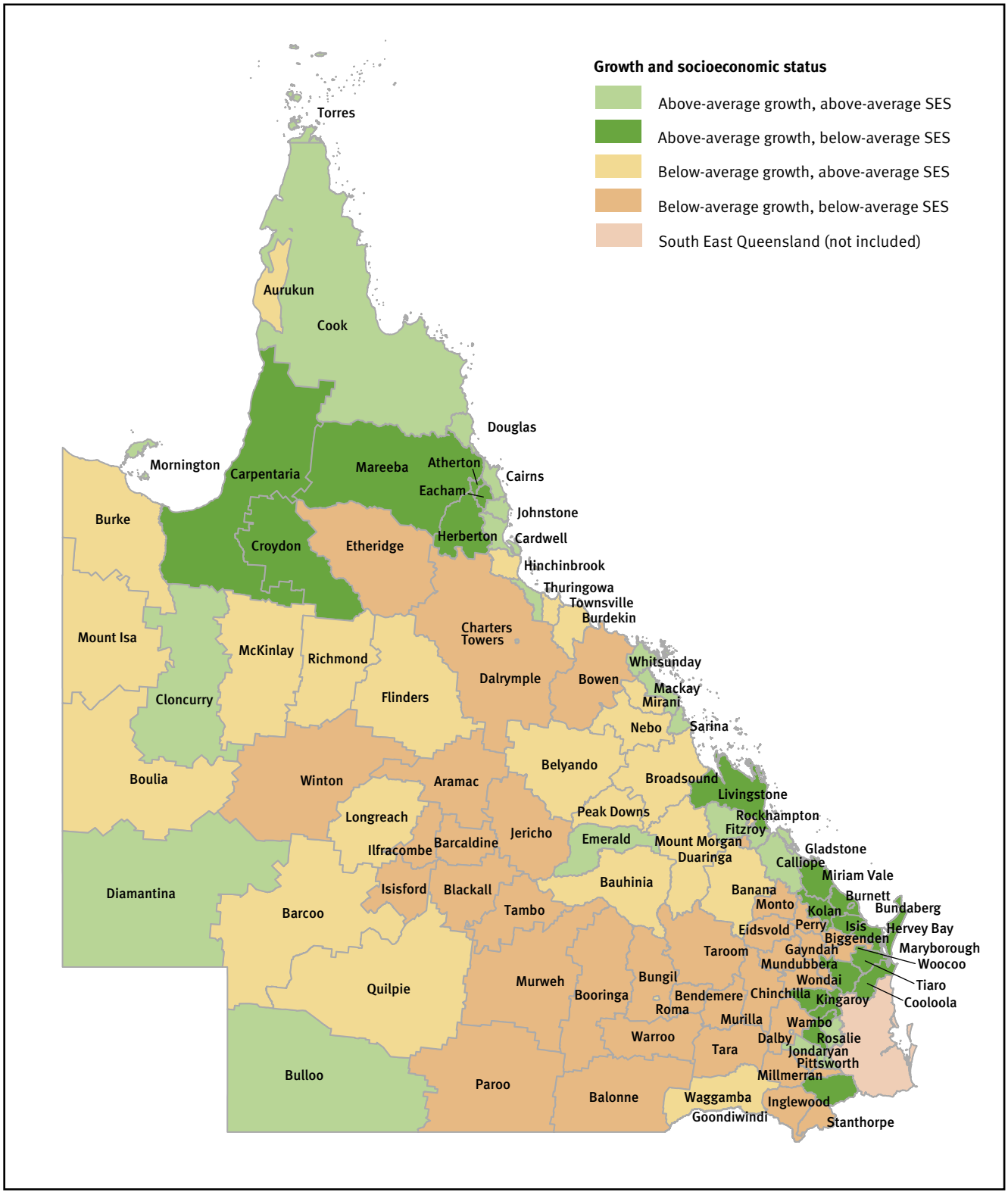


Figure 8.10 *Queensland LGAs (excluding South East Queensland), population growth and socioeconomic status (SES) dimensions, 1996*
Source: DLGP

(retirement/welfare), Bowen (agriculture) and Rockhampton (manufacturing). They concluded that small towns (between 4000 and 10 000 people) are generally struggling to adapt to changing economic and social conditions. Of 32 small towns in Queensland, they judged 19 to be economically vulnerable. They concluded that what is required is a place-specific policy response to deal with the economic and social variability of towns.

Unemployment

The distribution of unemployment in regions is related to the employment generation discussed above, but is also linked to local labour market factors. Table 8.12 shows the annual average unemployment rates in regions for the period 1996–2000, based on ABS labour market surveys. While unemployment rates in the South East, Darling Downs, South West and Wide Bay dropped between 1996 and 2000, Central Queensland had consistently high unemployment rates.



The number of people employed in the agriculture and mining sector has declined slightly since 1996. (Photo: J. Dunn, DLGP)

Table 8.12 Regional unemployment rates (annual average), Queensland, 1996–2000

Statistical Divisions	1996 (%)	1997 (%)	1998 (%)	1999 (%)	2000 (%)
Brisbane and Moreton	9.4	9.5	8.6	8.3	7.9
Darling Downs and South West	8.1	7.6	7.2	5.4	5.5
Wide Bay-Burnett	15.8	15.5	14.2	10.4	11.5
Fitzroy, Central West and Mackay	14.2	15.8	14.7	14.6	14.2
Northern and North West	9.0	10.5	10.1	8.6	8.9
Far North	7.7	9.2	7.2	7.4	7.7
Queensland	**9.3**	**9.5**	**8.7**	**8.1**	**7.8**

Source: OESR 2001

Responses

The Smart State

The 'Smart State' initiative of the Queensland Government is a package of measures responding to economic and global trends. This initiative aims to strengthen and diversify the economy in order to enable Queensland to be more competitive in the global marketplace. It involves industry assistance programs, education and training initiatives, the construction of research centres and high-technology infrastructure, and the development and implementation of strategic plans for the biotechnology and information and communication technology industries.

The total number of people employed in the Queensland information and communication technology industry in 2000–01 was 27 080, an increase from 22 987 in 1998–99 (ABS 2002a). This is a growth of 17.8%, which is slightly less than the growth for Australia overall (table 8.13). Surveys in Queensland also indicate that the sector is growing at around 10% a year (DIIE 2001).

Table 8.13 Employment in information and communication technology, Queensland and Australia, 1999 and 2001

	Persons employed 1989–99	Persons employed 2000–01	Percentage increase
Queensland	22 987	27 080	17.8
Australia	198 589	238 521	20.1

Source: ABS 2002a

Regional economic development

Economic conditions in regions and urban areas vary greatly across the state. Changing global and national economic conditions are creating opportunities for some areas and challenges for others. This requires both a broad statewide policy response and, as discussed previously, place-specific responses.

Queensland has adopted a regional approach to economic development through the Department of State Development (DSD) and its network of regional business centres. At a strategic level, this is guided by the State Infrastructure Plan (DSD 2001), which identifies opportunities for and constraints on regional economic development. It seeks to identify, prioritise and coordinate the provision of critical infrastructure to support economic development in the regions. It also provides a framework for negotiation about public–private partnerships for infrastructure provision. Ways to improve the State Infrastructure Plan are being explored; these include widening it to take in social as well as economic infrastructure and local government infrastructure, and improving avenues for regional community input to the plan.

Integrated planning

Economic considerations must be balanced and integrated with social and environmental considerations in decisions made under Queensland's integrated planning and development assessment framework. The State Infrastructure Plan developed by DSD, along with other relevant economic, environmental and social considerations, informs the economic development strategies of integrated regional planning frameworks. Regional planning frameworks, in turn, inform local planning decisions as local governments are required to coordinate and integrate the recommendations of regional planning advisory committees regarding regional economic development when they prepare their planning schemes.

Travel and transport

Summary

Passenger vehicle travel, in terms of total kilometres travelled, increased faster than population and economic growth over the past decade in Queensland. Most of this travel involves private cars. Between 1993 and 2000, the movement of road passenger vehicles increased by 28%. The patronage of public transport is increasing in South East Queensland. In relative terms, however, it is not keeping up with increasing car use, as the proportion of trips to work by public transport is declining.

Despite more efficient engines, fuel consumption in Queensland increased by 22% between 1998 and 2002, while the increase in Australia was 12%.

The increase in fuel consumption has led to higher emissions of air pollutants, including greenhouse gases. The level and cost of congestion in some areas have also increased, leading to an overall decline in liveability and environmental quality.

There are many reasons for the increases. Queensland's population and economic growth and human settlement patterns are influencing levels of vehicle ownership and travel demand. The use of private cars may be related to many factors, including convenience, the seemingly low marginal cost of use, increased demand from more women entering the workforce, the complexity of work and family trips, low-density urban patterns, the separation of work and home locations, and a perceived inadequacy of public transport services.

The future use of private cars will be constrained by limitations of road space in some areas, and congestion levels are already beginning to rise in parts of South East Queensland. Travel demand management and user-pays strategies are being considered and could assist in balancing travel demand and supply and in financing transport infrastructure.

A number of integrated regional and local transport plans have been prepared in response to these trends. The plans seek to give priority to public transport and freight movement.

Notwithstanding financial constraints, there have been significant infrastructure developments. These include Brisbane's South East and Inner Northern Busways, compressed natural gas buses with improved disabled access, CityCat ferries, the Pacific Motorway between Brisbane and the Gold Coast, new freight roads in central and western Queensland, and high-speed tilt train services between Brisbane and Cairns.

Integrated regional and local transport plans are key inputs in Queensland's integrated planning and development assessment framework. Regional planning advisory committees and local governments are required to coordinate and integrate these plans with a wide range of economic, social and environmental considerations when making decisions about Queensland's future development.

Pressures

Increasing travel and vehicle use

Travel demand in Queensland has increased faster than population and economic growth. Between 1993 and 2000, movement by road passenger vehicles increased by 28%, travel by rail increased by 20%, and road freight activity increased by 50% (Qld Transport 2002a). The factors behind this increased travel include greater participation of women in the workforce, continuing low-density urban patterns, low fuel costs, and just-in-time freight management (Qld Transport 2002a).

Figure 8.11 illustrates the continuing increase in motor vehicle usage in Queensland (because of changes in ABS data collection methodology, these figures are not directly comparable with those cited in 1999). The distance travelled by passenger vehicles registered in Queensland, for example, rose from 20 757 million km in 1998 to 25 320 million km in 2002, a 22% increase. Similarly, the distance travelled by all Queensland-registered vehicles rose from 29 822 million km in 1998 to 36 690 million km in 2002, a 23% increase (ABS 2002c, 2003b).



Passenger travel, mostly in private motor vehicles, is increasing faster than population and economic growth in Queensland. (Photo: L. Knight, EPA)

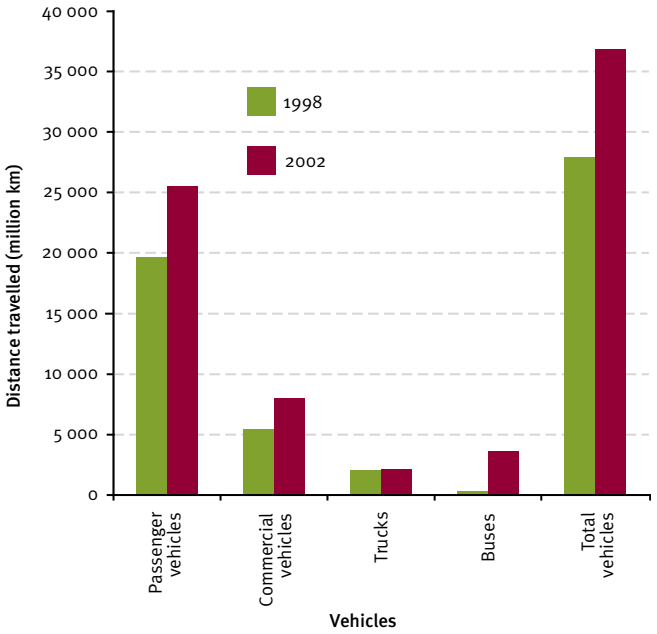


Figure 8.11 *Total vehicle kilometres travelled (million km) by type of vehicle registered in Queensland (12 months ended 31 July 1998 and 12 months ended 31 October 2002)*
Sources: ABS 2002c, 2003b

Two factors are contributing to these increases. The number of vehicles on the road is increasing, as is the average distance travelled by motor vehicles. The number of passenger vehicles registered in Queensland increased from 1 680 713 (0.456 cars per capita) in 1998 to 1 836 529 (0.486 cars per capita) in 2002 (ABS 2001a, 2002c). In the same period, the average distance travelled by passenger vehicles increased from 13 200 km to 14 300 km (ABS 2002c, 2003b).

Table 8.14 Average annual distance ('000 km) travelled by type of vehicle, Queensland and Australia

Type of vehicle	Queensland		Australia	
	Year to 31 July 1998	Year to 31 October 2002	Year to 31 July 1998	Year to 31 October 2002
Passenger vehicles	13.2	14.3	13.7	14.7
Buses	39.7	28.4	31.4	32.0
Articulated trucks	92.8	100.1	91.7	93.6
All vehicles	**14.6**	**15.7**	**14.9**	**15.6**

Sources: ABS 2002c, 2003b

Fuel consumption

The marginal improvements in the fuel efficiency of vehicles registered in Queensland—2.7% for passenger vehicles (ABS 2002c, 2003b)—was insufficient to offset the increase in vehicle kilometres travelled. The total annual fuel consumption by all vehicles in Queensland was 5049 million litres in 2002, a 22% increase since 1998. This compares with a 12% increase in fuel consumption nationally (table 8.15).



Motor vehicle travel and fuel use in Queensland are increasing. (Photo: A. Creed, EPA)

Table 8.15 Total fuel consumption (million litres) by type of fuel for all vehicles in Queensland and Australia

Type of fuel	Queensland		Australia	
	Year to 31 July 1998	Year to 31 October 2002	Year to 31 July 1998	Year to 31 October 2002
Petrol (all types)	2 663	3 170	15 539	16 507
Diesel	1 339	1 613	5 856	7 267
LPG/CNG	163	266	1 863	2 390
All fuels	**4 165**	**5 049**	**23 258**	**26 164**

Sources: ABS 2002c, 2003b

Condition and trends

Travel patterns and public transport use

Travel patterns in urban areas are very complex and therefore are difficult and expensive to measure in a comprehensive way. The national Census provides the most readily available and consistent time series information on personal travel patterns but covers only the journey to work. The figures for Queensland and Australia show that the private car dominates the journey to work and that public transport plays a small and declining role (table 8.16).

Public transport has a more significant role in the journey to work in South East Queensland, particularly in Brisbane. Public transport accounted for 10.1% of journey to work trips in 2001 (table 8.16), down from 11.3% of trips in 1991. Monitoring of public transport patronage in South East Queensland by Queensland Transport shows strong growth in the number of passengers (table 8.17), but the data in table 8.16 indicate that this may not be keeping up with the growth in population numbers and travel activity.

Table 8.16 Method of travel to work for employed persons, Queensland, South East Queensland and Australia, 1991 and 2001*

	Percentage Qld 1991	Percentage Qld 2001	Percentage SEQ 1991	Percentage SEQ 2001	Percentage Aust. 2001
Public transport (a trip that includes train, bus, ferry or tram travel)	7.7	7.4	11.3	10.1	10.9
Car (driver or passenger)	74.3	80.5	77.3	80.4	78.8
Bicycle or walked only	8.8	6.4	5.7	4.5	5.8

*Changes to the 'travel to work' question in 2001 mean the percentages are not directly comparable and should be used only as an indication of change over time.

Sources: ABS, Census of Population and Housing, 1991 and 2001

Table 8.17 Trends in public transport patronage in South East Queensland, 1999–2002

Transport provider	1999 (million passengers)	2002 (million passengers)	Percentage increase
Brisbane Transport	39.3	43.1	9.7
CityTrain	41.1	45.4	10.5

Source: Qld Transport 2002b

In many urban areas of Queensland, public transport services are generally provided by taxis and private bus services under contractual arrangements with the government. In South East Queensland similar arrangements apply. However, continuing population growth has placed pressure, in some areas, on the provision of additional and expanded services to meet increasing demands.

Congestion

An increase in vehicular traffic, particularly the use of private cars, in the context of limited road space, eventually results in increasing levels of congestion. Increasing congestion, in turn, leads to delays for people and freight, and also increases the emission of air pollutants and greenhouse gases.

Monitoring by Brisbane City Council and the Department of Main Roads has shown that the average travel times during peak periods on the main roads into the Brisbane CBD rose by over 7% between 1998 and 2000 (table 8.18).

Table 8.18 Travel times (minutes/km) into the Brisbane CBD, 1998–2000, averaged over five major CBD corridors, and percentage change

Travel time	1998	1999	2000	Percentage change 1998–99	Percentage change 1999–2000	Percentage change 1998–2000
Morning peak	2.09	2.10	2.24	+0.48	+6.67	+7.18
Afternoon peak	1.89	1.94	2.03	+3.17	+4.64	+7.41

Source: RCC 2002

Although the figures are somewhat dated, the Bureau of Transport Economics has forecast that the level and costs of congestion in Brisbane will continue to increase significantly.

Responses

Integrated planning

Integrated regional transport plans have been prepared for a number of regions and urban areas, including South East Queensland, Cairns, Wide Bay, Mackay and Townsville. These plans seek to integrate transport planning with wider land use and economic planning and to balance the needs and aims of different transport modes, including public transport, freight, private cars and cycling. In general, integrated regional transport plans seek to reduce car dependency and create opportunities for public transport and freight modes. These plans and other transport plans also guide the allocation of financial resources for new transport infrastructure. Translink is a partnership between Queensland Transport, Brisbane City Council, Brisbane Transport, Queensland Rail and private operators to centrally design, plan and integrate the public transport system in south-east Queensland.

State and local governments throughout Queensland have provided considerable new transport infrastructure in recent years. Projects include the Pacific Motorway between Brisbane and the Gold Coast, the South East Busway, new freight roads in central and western Queensland, the high-speed tilt train, the compressed natural gas buses and the CityCat ferries in Brisbane. A new rail link to Brisbane Airport (AirTrain) has been provided through a public–private partnership. Funding for transport infrastructure is a key challenge for governments, especially in SEQ, while the rates of vehicle travel growth exceed even the high rates of population growth. The experience of Europe and the USA is that it is not possible to just build your way out of congestion in this situation suggesting that some emphasis will need to shift toward more efficient travel and demand management.

Integrated regional transport plans and more localised transport plans are key inputs, along with other economic, social and environmental considerations, in decision making under Queensland's integrated planning and development assessment framework. Transport plans are intended to influence the infrastructure development strategies of integrated regional planning frameworks, which, in turn, influence local planning decisions as local governments are required to coordinate and integrate the recommendations of regional planning advisory committees regarding regional infrastructure development when they prepare their planning schemes.

Travel demand management

The increased use of private cars and rising traffic congestion in South East Queensland have necessitated the introduction of measures to manage the supply of and demand for travel and transport. Improved infrastructure for public transport and freight movement has been provided, but improved supply will not curb the growth in demand. Queensland Transport, in conjunction with local governments and other agencies, has worked on the development of a travel demand management measures. Priority measures for vehicles carrying multiple passengers, buses and freight trucks have been introduced in the form of T2 and T3 transit lanes, bus priority lanes, the South East and Inner Northern Busways, and priority freight routes.

TravelSmart

TravelSmart is a Queensland Transport voluntary behaviour change program to encourage people to use more environment friendly transport such as public transport, cycling, walking, carpooling and smarter use of the car. Over the next four years 69 TravelSmart projects focusing on suburbs, destinations, workplaces and schools will be undertaken throughout the state resulting in a reduction of 2 254 million vehicle kilometres travelled and emissions abatement of 719 290 tonnes (CO_2).



The AirTrain to Brisbane airport is one of a number of new transport infrastructure projects focusing on public transport use. (Photo: BCC)

Access for disabled people

Accessibility of public transport for physically disabled people in Queensland has increased greatly in recent years with the provision of more low-floor, wheelchair-accessible buses (figure 8.12).

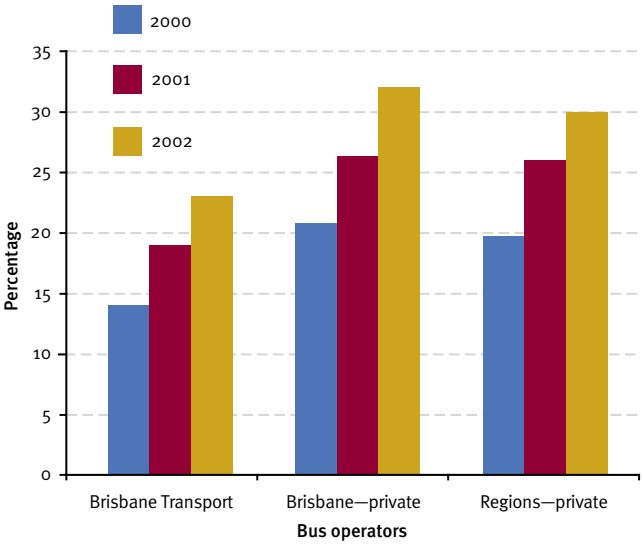


Figure 8.12 *Percentage of buses that are wheelchair-accessible, 2000–02*
Source: Qld Transport 2002b

Case study: South East Busway

The South East Busway was developed through the integrated regional transport planning process. It is a 16.5 km transport corridor providing an exclusive right of way for buses between the Brisbane CBD and Eight Mile Plains. It includes 10 purpose-built stations and links major activity centres, including the Cultural Centre, the Mater Hospital, the Gabba Cricket Ground, Griffith University and Garden City Shopping Centre.

Since opening in April 2001, the busway achieved:

- 1.81 million new public transport passenger trips;
- 84% growth in core busway service patronage; and
- 8% growth in patronage across all services accessing the busway.

Travel times on the busway in peak periods are around 1.05 minutes/km, which is less than half the travel time for cars and buses on other major routes (Qld Treasury 2002b). This relative travel advantage is central to the busway's attractiveness. The success of the South East Busway has led to the expansion of the busway network to other areas of Brisbane and provides a clear indication that this type of project can dramatically affect levels of public transport use.



South East Busway, Brisbane (Photo: QT)

Consumption of resources

Summary

Queensland has abundant non-renewable and renewable primary energy fuels and resources. The main sources of non-renewable energy are coal, oil and natural gas; the main sources of renewable energy are biomass, hydro and solar power. About 9.5% of Queensland's energy use comes from renewable sources; this is considerably higher than the figure for Australia.

Per capita energy consumption in Queensland is not only higher than the national average, but is also growing faster than the national rate. Electricity generation is the major user of primary energy fuels, followed by transport and the manufacturing sector. The commercial and domestic residential sectors represent a small percentage of primary energy fuel consumption.

Queensland has responded to the increase in per capita use of energy in several ways. In May 2000 it adopted the *Queensland Energy Policy: A Cleaner Energy Strategy* to establish a policy platform to diversify the state's energy mix towards greater use of gas and renewable energy sources, facilitate a supply of abundant and competitively priced gas, develop gas-fired power plants, and reduce the growth of greenhouse gas emissions. Other state energy initiatives include the Government Energy Management Strategy, which aims to reduce government energy consumption, and participation in the National Green Power Accreditation Program and the Energy Efficiency and Greenhouse Working Group formed by the Ministerial Council on Energy in 2002.

Nationally, urban uses account for some 25% of net total water use. Queensland's average domestic residential water consumption of 340 KL/household/year in 1996–97 was somewhat higher than the national average of 294 KL/household/year. There appears to be a declining trend in per capita water consumption in Brisbane, and relatively stable per capita consumption in Ipswich and the Gold Coast.

Improvements in urban water use may be due in part to national and state water reform processes, which have encouraged user-pays pricing policies, the use of more water-efficient appliances and better water resource planning.

State and local governments in Queensland have participated in national water reform processes under the national competition policy and the Council of Australian Governments (COAG) framework. The resulting creation of commercial water businesses has facilitated the application of pricing policies for cost recovery and water demand management. The Queensland Government has also passed legislation to facilitate its water reform, the *Water Act 2000*. The Act was fully proclaimed in April 2002.

In summary, insofar as resource inputs are concerned, per capita and total use of energy are increasing, while there are signs that per capita and total water use in urban areas are decreasing. Given Queensland's population, decreases in water use are encouraging. In light of Queensland's efforts to implement its energy policy, however, the increasing per capita rate of energy consumption is of concern.

Energy use—Pressure

Energy consumption

Queensland's per capita energy consumption is the third highest of all the states, after Western Australia and Victoria. The state's energy consumption is also higher than the national average and continues to grow faster than the national rate (figure 8.14 and table 8.19). In the eight years between 1992–93 and 2000–01, Queensland's energy consumption increased 15.2% to 281.1 gigajoules (GJ) per capita. In the same period, national consumption increased 12.4% to 259.7 GJ/capita.

Table 8.19 Energy consumption, Queensland and Australia, 1992–93 to 2000–01

	1992–93 (GJ/capita)	2000–01 (GJ/capita)	Percentage increase
Queensland	244.1	281.1	15.2
Australia	231.1	259.7	12.4

Source: ABARE 2003



Electricity generation is the major user of primary energy fuels. (Photo: EPA)

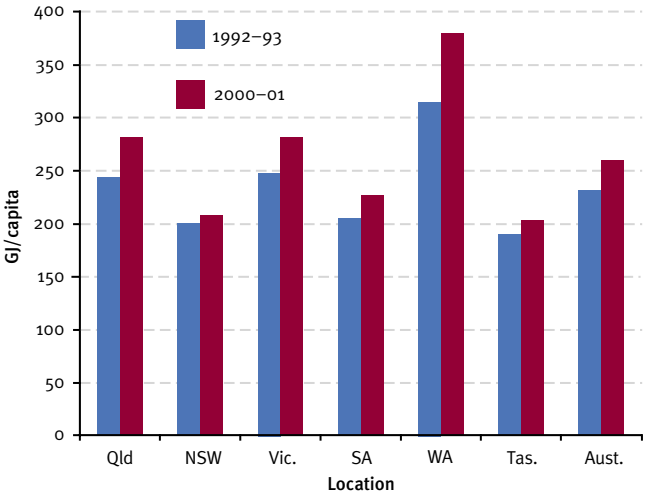


Figure 8.13 *Energy consumption (GJ/capita), Australian states and Australia, 1992–93 and 2000–01*
Source: ABARE 2003

Energy use in urban areas occurs in industries, in commercial buildings, in the movement of vehicles, and in people's homes. The growth in energy consumption per capita in Queensland reflects the development of more energy-intensive export and manufacturing industries, such as aluminium production, more energy use in transport, and growing energy consumption in the domestic sector (ABARE 2003). There is evidence that rising lifestyle aspirations are leading to the increase in per capita use of energy in homes in Australia (Foran and Poldy 2002). In Queensland, this is associated with a rapid uptake of domestic air conditioning and an increase in the floor area of dwellings. Figures for domestic electricity consumption per capita in South East Queensland show a 26% increase over the period 1990–2001 (RCC 2002).

Energy use—Condition and trends

Total energy use

Queensland's continued population and economic growth is reflected in an increase in total energy consumption from 849 petajoules (PJ) in 1994–95 to 1024 PJ in 2000–01 (table 8.20). Queensland's share of the nation's total energy use increased from 14% in 1973–74 to 19% in 1994–95 and 20% in 2000–01, while over the same period New South Wales reduced its share from 36% to 28%, and Victoria's share remained steady at 27%. Over the past six years, Queensland, Western Australia and the Northern Territory were the fastest growing energy consuming regions, all having annual average growth rates in excess of 3% (for Queensland the figure was 3.8%).

Table 8.20 Total end use energy consumption, Queensland and Australia, 1974–2001

	1973–74 (PJ)	1994–95 (PJ)	2000–01 (PJ)	Percentage increase 1995–2001
Queensland	371 (14.2% of national use)	849 (19.1% of national use)	1024 (20.1% of national use)	20.6
Australia	2615	4442	5083	14.4

Source: ABARE 2003

The major sectors and uses that consume energy in Queensland are shown in table 8.21. Electricity generation is the highest consumer, at 29.6% of the total end use energy consumption in the state, which is similar to the national proportion. Manufacturing and transport are also significant consumers, at 26.4% and 26% respectively. The Queensland agriculture sector proportion, although small, is significantly higher than the national figure, indicating the significance of this industry to the state. The commercial and residential sectors represent a relatively small percentage of end use consumption, and are also significantly lower than the national proportion.

Table 8.21 End use energy consumption, Queensland and Australia by sector, 2001

Sector	Queensland (PJ)	Percentage of Queensland total	Australia (PJ)	Percentage of Australian total
Agriculture	24	2.3	72	1.4
Mining	40	3.9	277	5.5
Manufacturing	270	26.4	1191	23.4
Construction	16	1.6	51	1.0
Transport	267	26.0	1278	25.1
Commercial	38	3.7	223	4.4
Residential	46	4.5	400	7.9
Electricity generation*	303	29.6	1474	29.0
Other	20	2.0	117	2.3
Total	**1024**		**5083**	

* Primary energy used internally within the electricity sector (does not include energy used in the production of electricity that is subsequently used by other sectors)

Source: ABARE 2003

Energy sources

Queensland and Australia have abundant non-renewable and renewable primary energy fuels and resources. In Queensland, the main sources of non-renewable energy are coal, oil and natural gas and the main sources of renewable energy are biomass, hydro and solar power (table 8.22). The main biomass used in Queensland is bagasse, a fibrous residue of sugarcane used as a fuel in sugar mills.

Table 8.22 Primary energy sources, Queensland and Australia, 2001

Energy source	Queensland (PJ)	Percentage of Queensland total	Australia (PJ)	Percentage of Australian total
Black coal	469	45.8	1393	27.4
Brown coal	0	0	665	13.1
Petroleum products	380	37.1	1780	35.0
Gas (incl. biogas)	78	7.6	979	19.3
Biomass	92	9.0	202	4.0
Hydro	4	0.4	60	1.2
Solar	1	<0.01	4	<0.08
Total	**1024**		**5083**	

Source: ABARE 2003



Remote area solar power supply systems provide clean power for outback settlements, such as the ranger station at Heathlands National Park on Cape York Peninsula. (Photo: L. Knight, EPA)

Energy use—Responses

Queensland Energy Policy

Renewable sources provide about 9.5% of energy used in Queensland. This figure is higher than the Australian figure of 6%, but almost all of the renewable energy is derived from bagasse and used in sugar mills (ABARE 2003). ABARE and the Office of Energy forecast that the use of renewable energy in Queensland will grow faster than total energy use.

The State Government adopted the *Queensland Energy Policy: A Cleaner Energy Strategy* (Qld Govt 2000) in May 2000. Key initiatives included:

- a licence scheme which will require electricity retailers to source 15% of electricity sold in Queensland from gas-fired or renewable energy from 1 January 2005;
- a requirement for 'a clear and demonstrated need' before generating licences are issued for new coal-fired power stations;
- strong encouragement for power stations burning fossil fuel to plant forests to offset up to 2% of their emissions;
- assistance for the coal industry to install equipment to capture and use waste mine gas;
- an increase in the Solar Hot Water Rebate to a $750 maximum, and an extension of the scheme until 2005. The proportion of Queensland homes using solar hot water systems rose from 4.8% in 1994 to 9.1% in 2001 (Qld Treasury 2002b);
- an extension of the Queensland Sustainable Energy Innovation Fund until 2005;
- support for collaborative research projects developing technology that would enable more efficient use of biomass to generate energy;
- an increase in the proportion of 'green energy' purchased by the Queensland Government from 2% to 5%;
- subject to the successful facilitation of gas into Townsville, the Government will build a gas-fired base load power station in Townsville, or negotiate the conversion of one or more of the existing peaking power stations in Townsville to gas and base load operation;
- the establishment of an Energy Efficiency Program to encourage electricity retailers to work with householders and small to medium businesses and to help them to use energy more efficiently; and
- continuing support for existing programs encouraging increased use of renewable energy and energy efficiency (such as the Remote Area Power Supply Rebate Scheme).

Water use—Pressure

Water consumption

An increasing population, economic growth and growing human settlements create pressures for increased water consumption. In urban areas, water is consumed not only by households and industries, but also by the water and sewerage industry itself. Climatic and rainfall conditions vary across the state and have a direct influence on the amount of water consumed. This is demonstrated by data on total water consumption available for the fourteen major urban water authorities in Queensland (WSAA 2001; AWA 2002), which show an average water consumption per capita of 220 kilolitres a year (KL/year) for 2000–01 (figure 8.14). The figures for different areas varied considerably, ranging from 118 KL/year (Maroochy) to 188 KL/year (Cairns), 269 KL/year (Brisbane) and 414 KL/year (Rockhampton).

Figures for longer-term trends in water consumption per capita are available only for the three cities of Brisbane, Gold Coast and Ipswich; these are shown on figure 8.15 (WSAA 2001; AWA 2002). This graph supports the view that water consumption per capita has decreased in urban areas in Australia over the past decade (Newton et al. 2001). This decrease has been linked to the introduction of water metering and pricing, to the use of more water-efficient toilets and other appliances, and to community education.

Water use—Condition and trend

Total water use

In Australia the rural sector is the largest consumer of water, accounting for some 70% of net total water use. The mining sector consumes 3%. Broadly, urban uses (manufacturing, electricity, water supply and households) account for some 25% of net total water use (ABS 2000). In 1996–97 the total amount of reticulated mains water supplied in Queensland was 1 367 844 megalitres (ML). Of this, some 774 553 ML, or 57%, was consumed by urban uses (ABS 2000).

Figures for longer-term trends in total urban water consumption are available only for the three cities of Brisbane, Gold Coast and Ipswich. Figure 8.16 shows data for 1993–94 to 2000–01. There appears to have been a decline in total water consumption through the 1990s in Brisbane and Ipswich and only a small rise in the Gold Coast, despite rapid population growth.

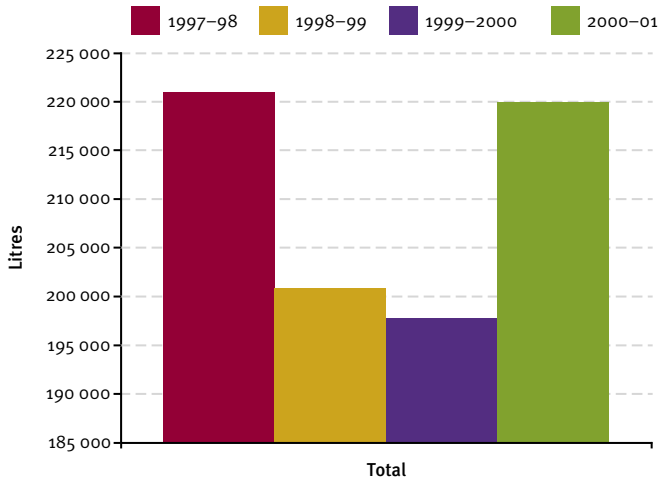


Figure 8.14 *Annual water consumption per capita in 14 urban water authorities, 1997–98 to 2000–01*
Source: DLGP, from WSAA and AWA reports

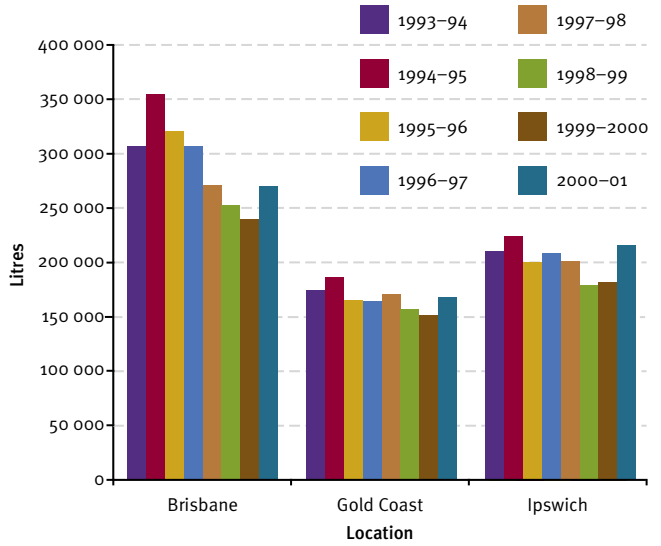


Figure 8.15 *Annual water consumption per capita for Brisbane, Gold Coast and Ipswich cities, 1993–94 to 2000–01*
Source: DLGP, from WSAA and AWA reports

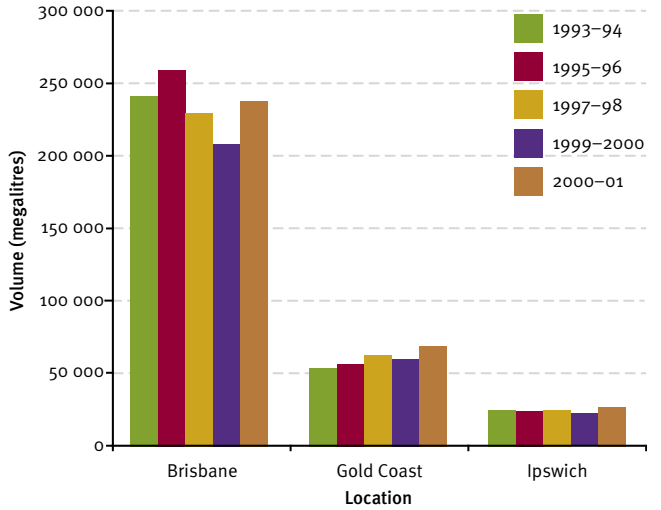


Figure 8.16 *Total water consumption for Brisbane, Gold Coast and Ipswich cities, 1993–94 to 2000–01*
Source: DLGP, from WSAA and AWA reports

Water use—Responses

Water reform

State and local governments in Queensland have participated in water reform processes under the national competition policy and the Council of Australian Governments (COAG) framework. The resulting creation of commercial water businesses has facilitated the application of pricing policies for cost recovery and water demand management. The Queensland Government has also passed the *Water Act 2000* to facilitate its water reform. The Act was fully proclaimed in April 2002. Under the Act, water resource plans are to be prepared for all major catchments and these will work to balance future rural, urban and environmental water needs. A major aim is to improve water use efficiency. Extensive community consultation is involved in preparing the plans.

Case study: Rockhampton Research House

As part of the Queensland Energy Policy and its greenhouse response, the State Government has developed guidelines for energy-efficient housing under the Queensland Development Code.

The Rockhampton Research House project is a facet of the practical research being carried out to test and improve these guidelines. This project involved the design, construction and use of a family home in central Rockhampton as a research centre for low-energy design, low water use, new building products and contemporary lifestyles. The Research House was opened in December 2001 and in May 2002 tenants moved in. Seventy-six sensors in the house collect a range of real-time performance data and this information can be accessed via the internet: ‹http://www.engineering.cqu.edu.au/researchhouse›. Central Queensland University is coordinating the research in aspects including:

- the effectiveness of roof cavity insulation and ventilation;
- detailed records of household energy and water use; and
- the efficiency of hot-water systems, including solar and high-efficiency gas systems.



Rockhampton Research House (Photo: DPW)

Waste outputs

Summary

Human settlements generate waste outputs in the form of solid waste, stormwater runoff and wastewater. (Stormwater is discussed in Chapter 5, 'Inland waters'.) Waste outputs can also be seen as a resource for urban areas: this has the benefit of reducing both resource consumption and environmental impacts.

While Queensland's per capita rate of solid waste generation is one of the highest in Australia, the amount generated decreased by 21% between 1996–97 and 2001–02. This was accomplished by an increase in both on-site disposal (by methods such as household composting) and recycling, and a decrease in amounts of landfill disposal. Because solid waste can result in the leaching of contaminants into the soil and groundwater, and can contribute to air pollution and greenhouse gas emissions, its disposal to landfill constitutes a major pressure on the environment. Waste from households is the largest contributor to landfill, followed by waste from construction and demolition sites, and commercial and industrial waste.

The total amount of solid waste sent to landfills is on the decline. This can be attributed to a number of measures taken since 1999, including the implementation of Queensland's *Environmental Protection (Waste Management) Policy 2000*, the development of the Queensland Waste Management Strategy, and the development of local and regional waste management strategies by local governments.

Urban wastewater generally contains excessive amounts of chemicals, pathogens or nutrients following its use for domestic or industrial purposes, and needs to be treated before it can be returned to a natural waterway. The data available on urban wastewater indicate that the amounts generated per capita have remained steady in the range of 108–118 KL/capita/year. The proportion of wastewater receiving tertiary treatment rose from 36% in 1998–99 to 48% in 2000–01.

The Queensland Water Recycling Strategy was released in December 2001 and is intended to encourage the use of wastewater, stormwater and rainwater as resources rather than wastes (EPA 2000a). The percentage of wastewater being reused is low and increasing slowly.

Pressures

Solid waste generated per capita

The solid waste generated by urban communities can be disposed of on-site (by methods such as household composting), recycled or sent to landfill. The figures for waste generated per capita relate to waste sent to landfill. Disposal of solid waste to landfill constitutes a major pressure on the environment. It can result in the leaching of contaminants into the soil and groundwater. Concentrations of odours and gases, including methane from the decomposition of organic waste, can lead to air pollution and greenhouse gas emissions. The construction and operation of landfill sites can also have significant detrimental impacts on ecosystems and biodiversity.

Figure 8.17 provides a comparison of landfill rates per head of population across Australia. Queensland's waste disposal rate of approximately 1350 kg/capita/year in 1996–97 was considerably higher than the national average of 1100 kg/capita/year (Newton et al. 2001). The amount of solid waste sent to landfill in Queensland subsequently fell by 21% to 1068 kg/capita/year in 2001–02 (EPA 2003b).



Figure 8.17 *Solid waste per capita sent to landfill, Australian states and Australia, 1996–97*
Source: Newton et al. 2001



Recycling and composting reduce the amount of household waste that is buried in landfills. (Photo: EPA)

Wastewater generated per capita

The amount of wastewater produced per capita by urban areas depends on the nature of the local population and economy, particularly the types of industries. Figures on total wastewater produced since 1997–98 are available from twelve of the major urban local governments in Queensland (WSAA 2001; AWA 2002). These account for over 60% of the state's population and include most of South East Queensland. The figures have been combined with estimated resident populations to produce figures on wastewater generated per capita. The average figure for 1997–98 was 113 KL/year. This rose to 118 KL/year in 1998–99 and fell to 108 KL/year in 2000–01. Longer-term figures from 1993–94 are available only for Brisbane City and the Gold Coast. While it is difficult to draw conclusions, the figures appear to indicate that the amount of urban wastewater generated per capita has remained relatively steady but fluctuates with climatic conditions.

Condition and trends

Total solid waste generated

The quantity of solid waste generated and sent to landfill in Queensland fell 13% from 4 428 800 tonnes in 1996–97 (ABS 1998) to 3 866 278 tonnes in 2001–02 (EPA 2003b). Municipal or domestic waste was the largest component (35.5%) of solid waste sent to landfill in 2001–02 (table 8.23). Factors contributing to the fall in solid waste disposal include waste minimisation action by local governments and industry, and increased rates of recycling.

Total wastewater generated and treated

Longer-term figures for total wastewater generated are available only for Brisbane City and the Gold Coast urban areas. In Brisbane City total wastewater generated increased from 91 000 ML in 1993–94 to 105 000 ML in 2000–01. In Gold Coast City, the figures for the same period were 37 000 ML and 49 000 ML (WSAA 2001; AWA 2002). These increases are in line with population growth in both cases.

Information on the levels of wastewater treatment are available for eight major urban local governments in Queensland since 1998–99 (WSAA 2001; AWA 2002). All are in South East Queensland. Virtually all of the wastewater from these areas received either secondary or tertiary treatment. Secondary treatment typically reduces the oxygen-depleting capacity (biochemical oxygen demand, or BOD) of the effluent by 90%, while tertiary treatment achieves significant nutrient removal and further reduces BOD.

Figure 8.18 shows the proportion of wastewater treated to either secondary or tertiary level between 1998–99 and 2000–01. The proportion treated to tertiary level increased from 36% in 1998–99 to 48% in 2000–01. The urban areas treating the highest proportion of wastewater to tertiary level in 2000–01 were Noosa and Caloundra (both 100%).

Table 8.23 Landfill rates by source, Queensland, 2001–02

Waste type	Landfill rate	
	t/year	kg/capita
Construction and demolition	644 591	178
Green and organic	286 000	79
Biosolids	171 651	47
Municipal	1 373 397	380
Commercial and industrial	577 445	160
Regulated	90 975	25
Landfill cover	722 219	199
Total	**3 866 278**	**1 068**

Source: EPA 2003b

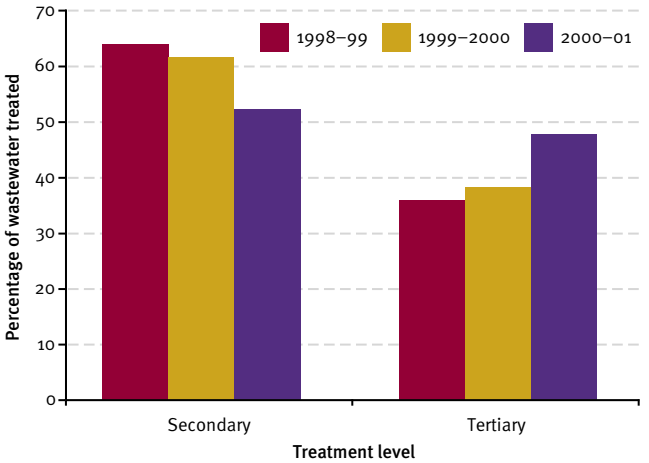


Figure 8.18 *Wastewater treatment levels, 1998–99 to 2000–01*
Source: DLGP, from WSAA and AWA reports

Responses

Management of solid waste

A new state policy framework for solid waste management was put in place by the *Environmental Protection (Waste Management) Policy 2000*. The EPA has worked with local governments and industry on the development of a Queensland Waste Management Strategy. This will set the framework for future directions for waste management in Queensland, reflect government intentions and identify the roles and responsibilities of different sectors in the community. Local governments have also been preparing waste management strategies individually or as groups of councils. The South East Queensland Regional Organisation of Councils (SEQROC) has prepared a regional waste management strategy. One of the main aims of these strategies is to increase solid waste recycling.

Both the quantity and percentage of solid waste recycled in Queensland increased significantly between 1996–97 and 2001–02 (table 8.24). Factors contributing to this increase include an increase in the number of local governments participating in recycling schemes, and an increase in the range of materials accepted through kerbside collection programs (figure 8.19).



The amount of solid waste that is recycled, either at or before the landfill stage, has increased. Some landfills sort deposited waste for reuse by other users. (Photo: EPA)

Table 8.24 Solid waste recycled, Queensland, 1996–97 and 2001–02

Year	Total amount of landfill (t)	Total amount recycled (t)	Percentage recycled
1996–97	4 428 800	174 600	3.9
2001–02	3 866 278	992 414	20.4

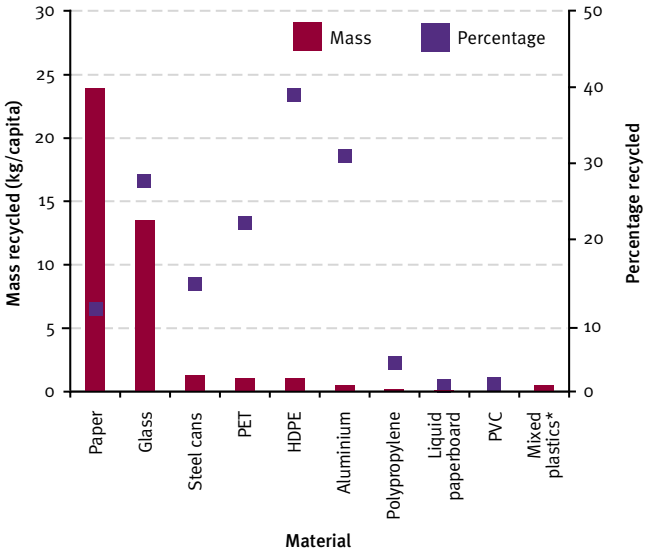
Sources: ABS 1998; EPA 2003b

Table 8.25 provides a snapshot of waste recycling in 2001–02. Biosolids and green and organic wastes had the highest recycling rates, while only 3.5% of commercial and industrial waste was recycled.

Table 8.25 Percentage of waste recycled by type, Queensland, 2001–02

Waste type	Recycling rate		Percentage recycled
	t/year	kg/capita	
Construction and demolition	329 718	91	33.8
Green and organic	343 526	95	54.6
Biosolids	239 892	66	58.3
Municipal	nil	nil	nil
Commercial and industrial	20 713	6	3.5
Regulated	58 644	16	38.2
Landfill cover	nil	nil	nil
Total	**992 413**	**274**	**20.4**

Source: EPA 2003b



*No percentage data available for mixed plastics

Figure 8.19 *Recycling rates for household materials, Queensland, 2001–02*
Source: EPA 2003b

The recycling of household waste occurs through kerbside recycling bins, bags and drop-off centres. In 2001–02, 87% of Queenslanders had access to a household recycling program. They recycled 150 449 tonnes of materials, or 41.6 kg/person. This represents a 6% increase on the 141 451 tonnes recycled in 2000–01. The main recycled materials (by mass) were paper, newsprint and cardboard (23.9 kg/capita) and glass (13.5 kg/capita). The most recycled materials (proportion of waste stream diverted from landfills) were HDPE plastics (39%), aluminium (31%), glass (28%) and PET plastics (22%) (figure 8.19).

Wastewater treatment and reuse

One response to the environmental impact of increasing volumes of wastewater is to increase the level of treatment. Concern over the impact of wastewater on Moreton Bay was a contributing factor to the increase in the volume of wastewater receiving tertiary treatment in South East Queensland; the proportion rose from 36% in 1998–99 to 48% in 2000–01.

The Queensland Water Recycling Strategy was released in December 2001. It encourages the recycling of wastewater, stormwater and rainwater, treating them as resources rather than wastes (EPA 2001a). The focus of the strategy is on education, trial projects, and amending regulations.

The proportion of wastewater being reused in Queensland is low, and is increasing only slowly. Information on levels of wastewater reuse since 1998–99 is available for nine major urban local governments (WSAA 2001; AWA 2002). The proportion grew from 4.2% in 1998–99 to 5.7% in 2000–01 (figure 8.20). The local governments reporting the highest proportions of wastewater reuse in 2000–01 were Hervey Bay (67%), Gold Coast (9.6%) and Caloundra (9%).

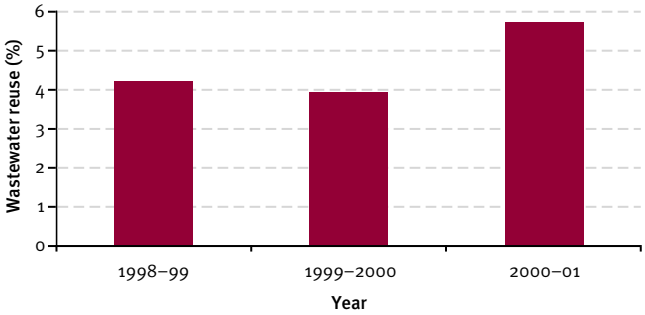


Figure 8.20 *Percentage of wastewater reuse, Queensland, 1998–99 to 2000–01*
Sources: WSAA 2001; AWA 2002



Treated wastewater can be recycled for other purposes, such as irrigation. (Photo: EPA)

Case study: Townsville Biogas

Methane and associated gases (biogas) produced in the treatment of wastewater can be used as a resource to produce electricity. The Townsville Biogas project, a joint project by Citiwater Townsville and the Stanwell Corporation Limited, is using wastewater in this way (AWA 2002). Two electricity-generating units have been installed in the sludge digester tanks of the Mount St John wastewater treatment plant and the Cleveland Bay water purification plant. Each unit produces 115 KW and is expected to generate 880 MWh per year. This represents 90% of the electricity required to run the Mount St John plant and 30% of that required to run the Cleveland Bay plant.

The environmental benefits of using wastewater to generate electricity include reduced air pollution, reduced greenhouse gas emissions and reduced use of other resources to produce electricity.



Biogas from the treatment of wastewater is used to produce electricity at the Townsville Biogas project. (Photo: EPA)

Liveability

Summary

The liveability of human settlements is a product of many factors that affect people's wellbeing. An individual's opinion of quality of life is usually based on some combination of the perception of employment opportunities, housing affordability, ease of mobility or access to public transport, health and community services, access to cultural and social activities and the availability of open space, parks and recreational opportunities.

Liveability is affected by both positive and negative factors. Effective and efficient public transport can contribute to ease of mobility and access while reducing traffic congestion, air pollution and noise. Conversely, the lack of good public transport can contribute to reduced liveability. Unfortunately, we currently lack statewide data to evaluate many of the factors typically used to determine liveability. This section uses the data that are available, primarily for South East Queensland.

Most Queensland residents rate their quality of life as high. Continuing steady employment growth, relatively good housing affordability and high levels of community health contribute to the perception of liveability. The growth and change of urban areas and increased visitor numbers can have negative impacts on liveability. These impacts include rising levels of traffic congestion, declining rates of public transport use, increasing noise complaints, and socioeconomic disparities within and between communities.

Not all Queenslanders benefit equally from the state's prosperity; 4.6% of the population lives in areas considered to be disadvantaged. These include areas on Brisbane's metropolitan fringe as well as rural and Indigenous communities in remote areas. The Queensland Government established a Community Renewal Program in 1998, aimed at the coordinated delivery of a range of services and physical improvements to areas experiencing high levels of social and economic stress.

Community wellbeing is one of three components of ecological sustainability under Queensland's integrated planning and development framework. This framework requires liveability and other social aspects to be balanced and integrated with economic and environmental considerations in decision making at state, regional and local levels.

Progress is being made in open space and urban design. Regional planning advisory committees are giving strategic direction on regional open space, and at the local level there is a growing trend for policies and practical initiatives to maintain and improve the quality of public spaces through urban design, to link residential areas with cycle paths and pedestrian walkways, and to protect areas of green space for environmental and recreational purposes. Initiatives include new medium- and high-density residential areas that are integrated with public open space and walkways, and the Goodwill Bridge for pedestrians and cyclists that links the Brisbane CBD with some of its river precincts. A number of local governments have funded the purchase and management of bushland and open space by introducing special environmental rates, or 'green levies'. Recent studies on the demand for outdoor recreational activities have noted the need for more places catering for outdoor activities, and the need to anticipate future demand arising from population growth. It seems that interest in outdoor activities is growing and people are becoming more aware of the health benefits of active recreation.

Whether something detracts from or contributes to liveability is to some degree a matter of personal perspective. This means that high-density living, with its vibrant urban lifestyle, is the ideal for some. Others may find that the noise and lack of open spaces detract from their perceived quality of life. Changing demographics, economic conditions and lifestyle preferences suggest that governments and planners will need to continue to anticipate the needs and aspirations of residents and visitors in the future.



Open space is highly valued for recreational activities in inner-city and high-density residential areas. (Photo: L. Knight, EPA)



The number of complaints about noise in South East Queensland has increased substantially since 1998. (Photo: EPA)

Pressures

Population and economic growth put pressures on the liveability of urban areas but can also increase liveability. Urban growth can threaten liveability by degrading aspects of the natural and built environment through loss of remnant vegetation, increased pressures on open space, increased noise levels, higher housing costs and increased traffic congestion. Urban growth can also increase liveability by providing greater employment, social and cultural opportunities and facilitating better public transport infrastructure.

Noise

Excessive noise from transport, industry or the activities of other residents can seriously diminish people's quality of life. There were 12 956 noise complaints to Queensland local governments in 1999–2000, 18 655 in 2000–01 and 17 862 in 2001–02 (EPA 2000, 2001b, 2002b).

Condition and trends

Community attitudes

Queenslanders generally rate their quality of life as high. In a household survey carried out across the state in November 2001, people were asked how satisfied they were with their quality of life. A total of 91% of people said they were 'satisfied' or 'very satisfied' (Qld Treasury 2002b). The survey found that women were more likely than men to be very satisfied with their quality of life.

In 2001, the South East Queensland Outdoor Recreational Demand Study found that a high proportion of people in the region participated in a variety of outdoor recreational activities. While the study demonstrated that age, sex and location have a major influence on participation rates, people strongly value the provision of accessible open spaces that are retained as much as possible in their natural condition. Further, the study found that a shortage of places catering for outdoor activities is a cause of increasing concern and that for health reasons more people would like to participate in outdoor activities than currently do (SRQ 2001). The availability of land for open space and recreation is integral to the liveability of Queensland's human settlements. The benefits associated with open space and recreation accrue to the individual, the environment, the community and the economy. These benefits include opportunities to learn about nature and physical health, protect wildlife, enhance air quality, preserve environmentally significant lands, reduce flooding and erosion, interact with others for recreation and social purposes, and improve local economies through tourism and businesses.

Community wellbeing

The life expectancy of most Queenslanders is high and has increased steadily over the past 20 years. However, the median age at death for Indigenous males and females—53 years and 61 years, respectively—remains significantly lower than for non-Indigenous males and females—76 years and 82 years, respectively (Qld Treasury 2002b). The difference in life expectancy appears to be due largely to the high prevalence of chronic diseases such as diabetes and cardiovascular and renal disease in Indigenous peoples.



Walking and other exercise maintain physical activity and can reduce the amount of motor vehicle travel for short trips. (Photo: BCC)

Recent national surveys show a decline in the overall number of people who achieve sufficient levels of physical activity for health benefit. Nationally, the proportion of the population defined as 'active' declined from 62% in 1997 to 56% in 2000. Queensland was one of the 'least active' states (Mummery et al. 2002). Low-density suburbs, where cars are perceived to be required for most trips, also tend to reduce walking opportunities and thus reduce activity levels. A recent survey by Queensland Transport indicated that while 67% of Queenslanders walk to a destination daily or at least a few times a week, 13% never walk to a destination (Qld Transport 2003).

While tourism has social and economic benefits, it can pose risks to health and community wellbeing. Overseas visitors increase the risk of importation of serious infectious diseases such as measles and dengue fever. The majority of measles cases in Queensland are in overseas visitors who are unvaccinated or are from countries without measles vaccination programs. A recent outbreak of over 400 cases of dengue fever in north Queensland was linked to an infected visitor case. Good surveillance systems are required as the range of the mosquito vector for dengue includes more than half of Queensland. The potential impacts of imported infectious diseases include health risks to the Queensland population, impacts on health services, and potential impacts on business, including tourism, if outbreaks result in travel warnings.

Housing affordability

Housing affordability is an important component of liveability for urban residents. Affordable housing can also be an important factor in attracting new businesses and residents to an area.

The Commonwealth Bank and the Housing Industry Association have developed an index of housing affordability; this is the ratio of average household disposable income to the income needed to meet loan repayments for a typical dwelling. The CBA-HIA housing affordability index is based on household incomes, house prices and interest rates. Figure 8.21 plots housing affordability for Brisbane and the rest of Queensland over the period June 1996 to June 2003. The graph shows a sharp decline in affordability since 2001.

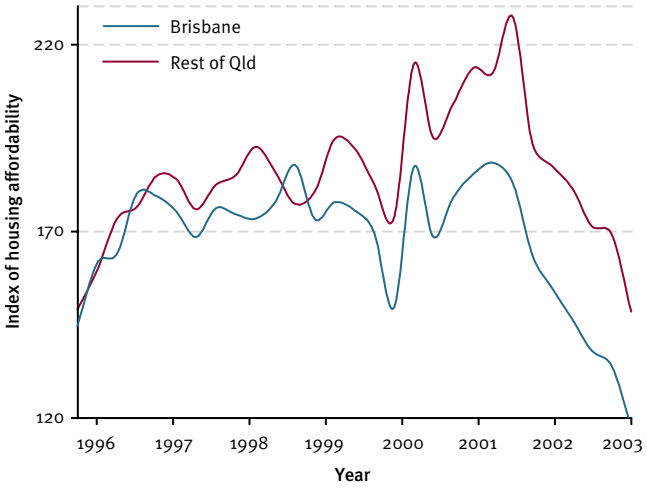


Figure 8.21 *Housing affordability in Brisbane and the rest of Queensland, June 1996 to June 2003*

Areas of disadvantage

While the Australian economy has grown steadily over recent decades, the benefits of growth are not being shared equally. This has resulted in a polarisation in income and access to material resources, and has the potential to reduce liveability by increasing conflict, crime and insecurity (Newton et al. 2001).

The ABS has developed composite socioeconomic indexes for areas (SEIFAs). One of these, an index of relative disadvantage, is based on attributes such as low income, high unemployment and low educational levels. Areas where the index is less than 900 are considered to be disadvantaged. The indices from the 2001 Census were not available when this report was prepared. In 1996, however, 32 areas accounting for 4.6% of the population of Queensland, or around 153 600 people, were considered to be relatively disadvantaged. These areas include outer metropolitan parts of South East Queensland, a number of areas in the Wide Bay region and Indigenous communities around the Gulf of Carpentaria (figure 8.22).

Responses

Community renewal

In response to the issue of urban disadvantage, the Queensland Government established a Community Renewal Program in September 1998. It involves the coordinated delivery of a range of services and physical improvements to areas experiencing high levels of social and economic stress. The goal of the program is 'to reduce the level of disadvantage and raise the confidence and image of identified communities' (DH 2002).

Fourteen urban communities and one remote Indigenous community (Palm Island) have been involved in the program to date. These communities include fringe urban areas in Brisbane, Townsville and Cairns. Evaluations of some projects indicate that in Garbutt in Townsville, 78% of people considered that progress had been made in creating a 'strong and thriving' community but only 28% considered that progress had been made on 'better public transport'. At Manoora in Cairns, an evaluation concluded that 'significant' progress had been made on improving community safety but only 'very modest' progress had been made on job creation (DH 2002).

The provision of infrastructure to support healthy Indigenous communities (such as clean water, effective sanitation services and appropriate housing) is a high priority for the Queensland Government. The establishment of the Indigenous Environmental Health Government Agency Group will ensure whole-of-government coordination of service delivery to improve living conditions within Indigenous communities. The implementation of the Queensland Health Aboriginal and Torres Strait Islander Environmental Health Strategy 2001–2006 should also improve the capacity of communities to achieve better environmental outcomes.

Integrated planning for open space and recreation

Although no statewide data are currently available on the proportion of urban land conserved as green space, there is regional information for South East Queensland that was generated as part of the performance monitoring of the South East Queensland Regional Framework for Growth Management 2000 (RCC 2002). Therefore discussion is limited to the data that are available on the percentage of the region with protected area status and on outdoor recreational demand. Protected areas, including areas protected under the *Nature Conservation Act 1992* (for example, national parks and conservation parks) and state forests, are an important component of green space. In South East Queensland in 1995, 14% of the region had protected area status; in 2000 the protected area had grown to 15.4% of the region (DLGP 2002). This increase is likely to be due to the continuing conversion of state lands with conservation values to protected area status and to targeted acquisitions.

Sport and Recreation Queensland is the lead state agency responsible for sport and recreation policies. It provides expertise on planning and development of open space, recreation and parks. It also provides financial assistance to local governments for recreational planning and facilities through the Local Government Development Program. This program has provided $10 million over a three-year period beginning in 2001 to support recreation and sport opportunities.

At the regional level, regional planning advisory committees have been providing strategic direction for a wide range of aspects affecting liveability, including the conservation of open space. The South East Queensland Regional Landscape Strategy is a government response to the need to recognise and promote open space. The South East Queensland Regional Framework for Growth Management 2000 called for the development of a regional landscape strategy. This strategy will identify regionally significant open space; coordinate, develop and maintain open space; integrate existing open space processes of state and local governments; and provide for outdoor recreation (EPA 2003a).

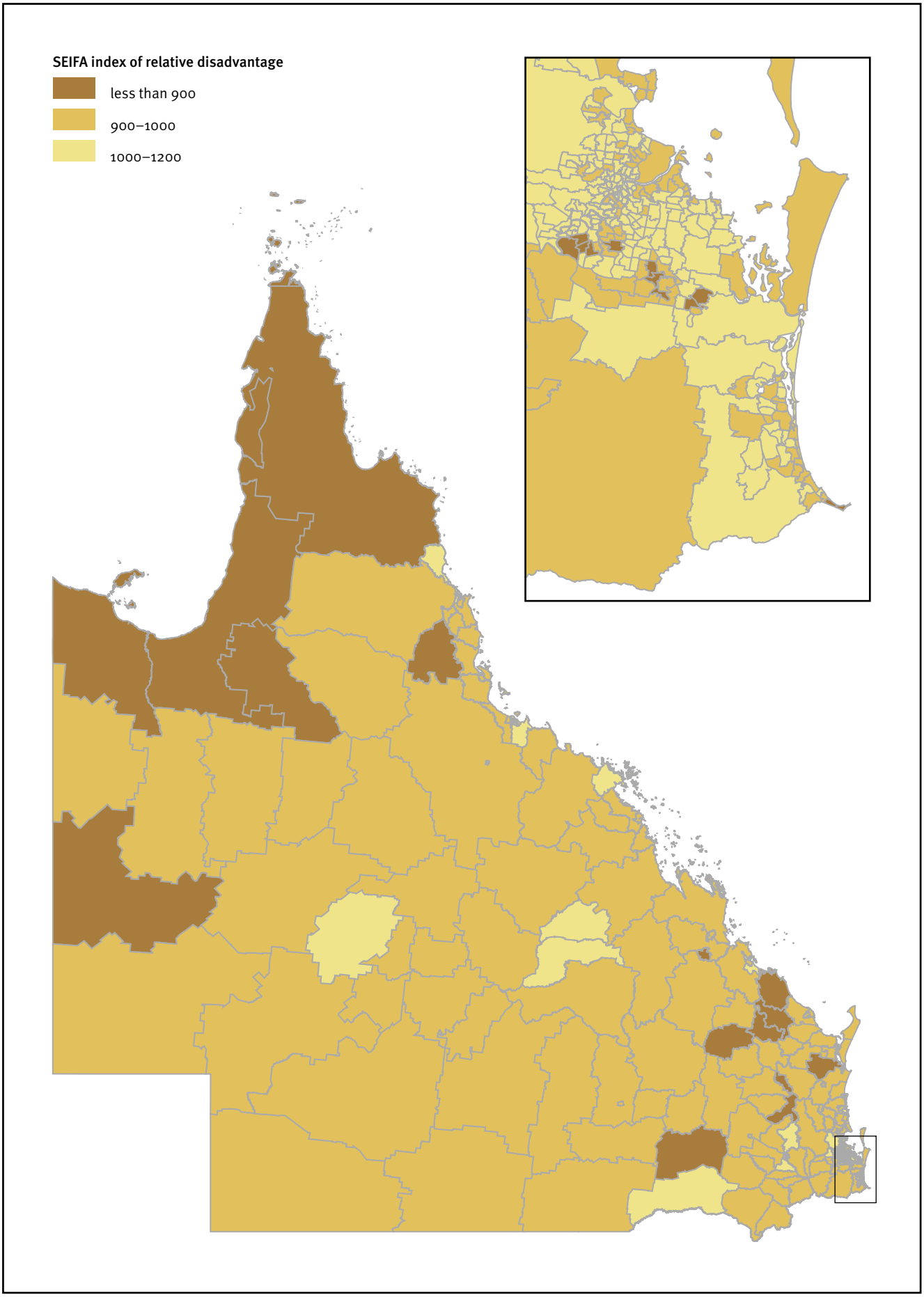


Figure 8.22 *Areas of relative disadvantage by local government area, Queensland, 1996*
Source: ABS



Public open spaces, such as New Farm Park in Brisbane, need to be protected for environmental and recreational purposes. (Photo: BCC)

As urban areas become larger and densities increase, the population pressures on public spaces grow. Consequently, it becomes more important to maintain and improve the quality of public spaces through urban design, link residential areas with cycle paths and pedestrian walkways, and protect areas of green space for environmental and recreation purposes.

In Brisbane, at major redevelopment areas such as New Farm, new medium- and high-density residential areas are being designed and created to be integrated with public open space and walkways. The Goodwill Bridge for pedestrian and cyclists was recently opened to improve links between the Brisbane CBD and the south bank of the river. In other LGAs, such as Caboolture and Rockhampton, existing urban public spaces —parts of the central city, town centres and suburban strips, for example—are being redesigned and refurbished to ensure their economic and social vitality. These local government initiatives are assisted financially by the Queensland Government through its Regional Centres Program.

A significant number of local governments in Queensland have also introduced special environmental rates, or 'green levies', to fund the purchase of bushland and open space, its management and community education (LGAQ 2001). Local governments have also redesigned and revitalised existing areas of urban open space and public land, such as the Cairns, Townsville and Redcliffe foreshores, to better meet the needs of their communities and visitors.

Case study: 10 000 Steps Rockhampton

Walking is a key contributor to health and an increased sense of wellbeing. The physical layout of much of our urban areas, however, does not encourage walking. '10 000 Steps Rockhampton' is a community-based health promotion project, based in Rockhampton City, aimed at encouraging more people to walk (Mummery et al. 2002). The project, started in 2001, focuses on engaging socioeconomically disadvantaged and sedentary adults, including older and unemployed people. The project provides pedometers as a self-monitoring tool to help individuals achieve the activity target of 10 000 steps daily.

An initial baseline survey of Rockhampton residents identified the need to cross heavy traffic and busy streets and the poor condition of neighbourhood footpaths and street lighting as barriers to increased walking. In response to these concerns, the Rockhampton City Council has developed a series of marked and metered walking paths across the city. These paths are being completed at the rate of one a month. People's response to the program has been positive and the next phase will involve research into the individual and community health benefits (Mummery et al. 2002).



A riverside walk has been developed in conjunction with the '10 000 Steps' project. (Photo: J. Abbott, DLGP)

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Suburbia (Photo: EPA)

9 Natural and cultural heritage

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Authors

Stewart Armstrong, Natalie Franklin, Cameron Harvey, Lachlan Hurse and Karen Murphy, Environmental Protection Agency

Reviewers

Sharon Sullivan, Sullivan Blazejowski and Associates
Jane Lennon, Jane Lennon and Associates Heritage Consultants

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Introduction

The environment—built, natural and social—provides the context in which people live their lives. Daily interactions with the environment help to shape personal and community identities and influence the way people live. In a world where attitudes and values are rapidly changing, and where our surroundings are subject to change, people need to maintain tangible links with the past.

The term 'natural heritage' is used to describe the physical, biological and geological features that have natural significance to the community. Queensland's natural heritage includes places with significant ecosystems, biodiversity or geodiversity, and places with important science and conservation value, indigenous species of animals and plants, and natural beauty.

'Cultural heritage' is the term used to describe everything we have from the past, including the recent past. It includes places we value for their association with our own past lives and the history of our communities. Our cultural heritage includes objects and artefacts, documentary records and works of art; it incorporates our religious beliefs, folklore, ideas, memories, skills and practices. Cultural heritage covers aspects of both Indigenous heritage and historical heritage. Indigenous cultural heritage refers to the heritage places, objects and intangible aspects of the first inhabitants of Australia. Historical cultural heritage refers to the heritage places, objects and intangible aspects of Australian culture since 1788.

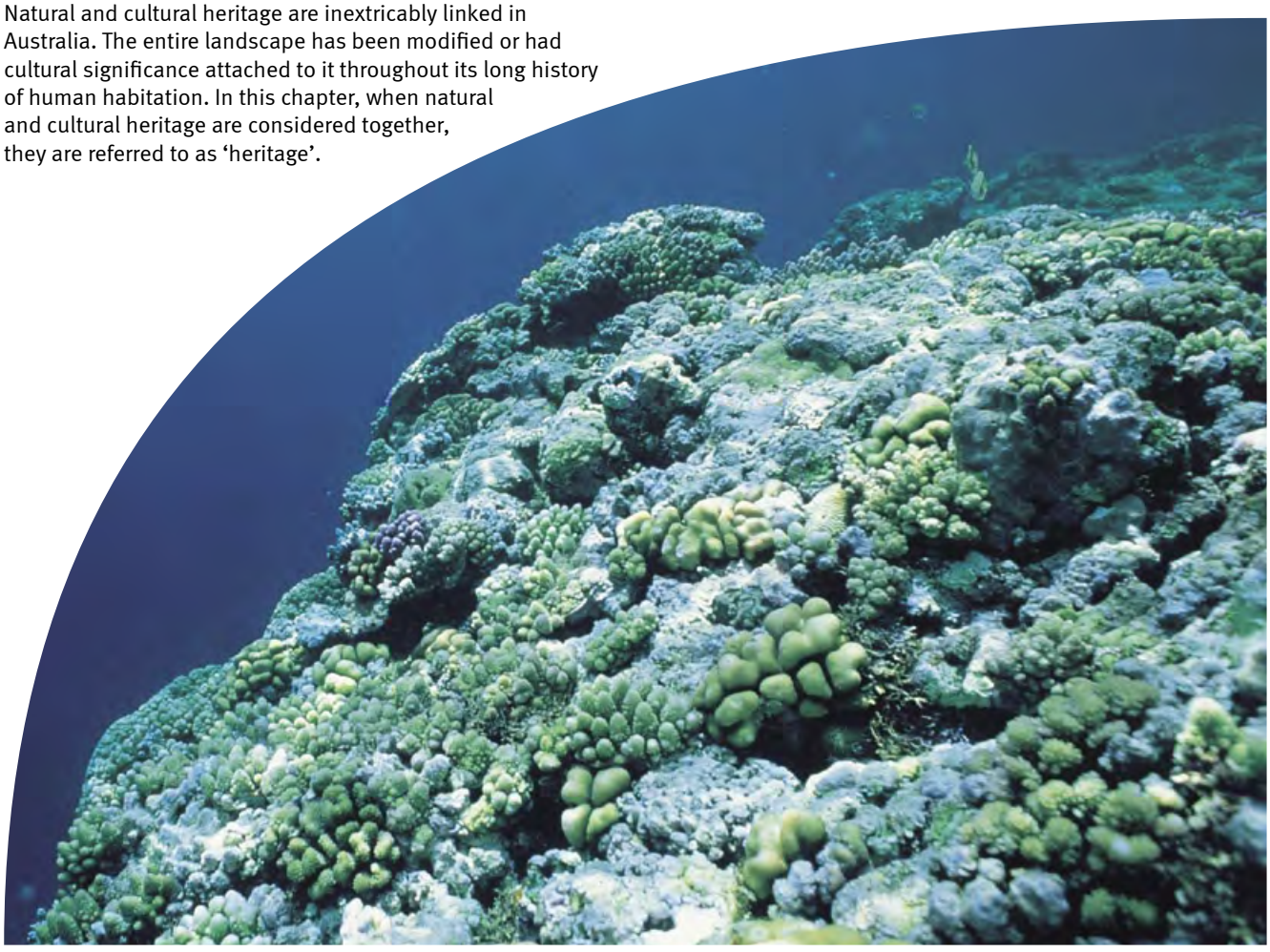
Natural and cultural heritage are inextricably linked in Australia. The entire landscape has been modified or had cultural significance attached to it throughout its long history of human habitation. In this chapter, when natural and cultural heritage are considered together, they are referred to as 'heritage'.

This chapter examines heritage issues in four sections:

1. Knowledge of Queensland's heritage;
2. Assessing the condition of Queensland's heritage;
3. Protecting Queensland's heritage; and
4. Community awareness and support.

Queensland's first state of the environment report, published in 1999, discussed the issue of cultural heritage. The 2003 report goes further, discussing natural heritage also. It identifies trends by examining the previous and current data; these will assist in the formulation of policies regarding heritage issues. It will also help raise public awareness of the challenges facing heritage in Queensland.

The report uses measurable indicators to examine natural and cultural heritage trends. A review of the 1999 indicators was made for this report in light of indicators used by Lennon et al. (2001) in the national state of the environment report. The 2003 report uses 27 of the indicators used in 1999 and includes 21 new ones: five for natural heritage, five for government funding and support, five for Indigenous languages, two for condition and damage at cultural heritage places, two for heritage professionals and training, one for membership of community heritage organisations, and one for conservation treatment of collections.



Knowledge of Queensland's heritage

Summary

There has been an overall upward trend in the number of places being listed in registers or inventories for heritage values and steady growth in heritage collections since 1999. Many heritage places, however, are not reported to government agencies and other groups responsible for heritage in this state.

Most identification, documentation or assessment of cultural heritage places is done in response to the threat of development. No systematic survey for heritage places has been undertaken at a statewide level. As a result, there is increased potential for certain types of heritage places to be comparatively neglected. Even a cursory examination of the numbers and types of Indigenous heritage places recorded on the state's Indigenous Sites Database reveals an over-representation of archaeological places. Although Indigenous people play a significant role in heritage surveys and assessments, the lack of standardised measures in the Indigenous Sites Database for the recording of scientific or cultural significance compounds the problem. There continues to be no formal register of Indigenous heritage places in Queensland. The only register or inventory that requires any detailed assessment for entry is the Commonwealth's Register of the National Estate, meaning that rigorous significance assessments for Indigenous heritage places are conducted infrequently.

A focus on the assessment of the more prominent historical heritage places has the potential to result in ignorance of certain types of heritage places and/or periods of history. The Queensland Heritage Register, which records places and protected areas deemed to have cultural heritage significance, is dominated by places in highly developed areas, such as south-east Queensland. Just over 32% of all places permanently or provisionally entered in the Register are in the Brisbane City Council area. Regional centres along the east coast such as Townsville City and Rockhampton City are also well represented. The majority of local government areas in other parts of the state feature few, if any, places in the Register. There is little interest in or active protection of the many other places of historical heritage value throughout the state that would not meet the strict criteria for entry in the Register.

Cultural heritage places in Queensland are being ignored as candidates for entry on international heritage lists, even though many natural heritage places that are listed clearly also have significant cultural heritage values. Conversely, a formal register of natural heritage places, similar to the Commonwealth's Register of the National Estate, is absent at the state level. Research programs conducted by a range of institutions continue to provide us with knowledge about our natural heritage, however, and mapping of vegetation and regional ecosystems is continuing, 45% of the state now having been mapped (EPA 2003; see also Chapter 7, 'Biodiversity').

Museums are currently experiencing difficulties in accessioning and cataloguing their heritage collections as a result of changing workplace priorities and limitations in time and resources. Smaller museums are believed to be facing similar problems.

While the identification and recording priorities for natural, historical and Indigenous heritage places are different, current recording methodologies result in serious limitations to the extent of our knowledge. Consequences include an inability to provide adequate protection for and management of all aspects of Queensland's heritage, especially cultural heritage, and a hindrance to any effort to improve heritage conservation in the state.

Description

Our state of knowledge of heritage in Queensland is defined in terms of the number and distribution of heritage places and collections. Knowledge, including an understanding of the values associated with heritage places and collections, is essential for the effective management of heritage. The number and distribution of heritage places are considered at international, national, state and local levels, while heritage collections throughout Queensland are also discussed.

The indicators used to examine knowledge of Queensland's heritage are based on indicators used in 1999 (EPA 1999a). However, as the focus of this chapter has been broadened to include elements of natural heritage, the indicators have been redefined. A new indicator has also been included to report on the state of knowledge concerning Queensland's protected areas.

Pressures

Development activity continues to be the major pressure on cultural heritage places in Queensland. The result is an increase in pressures on the professional heritage community, government agencies and other interest groups to provide appropriate levels of recognition for cultural heritage through adequate identification, documentation and assessment.

Our state of knowledge of Queensland's natural heritage is reliant on continued support for environmental research programs in areas of potential natural heritage significance and those already accorded protected area status (for details, see 'Protecting Queensland's heritage', page 9.32).

The ability of collecting institutions to provide adequate curatorial services and effective collection management is being threatened by shifting work priorities and limited financial and human resources.

Condition and trends

World Heritage

The number of Queensland sites listed under the UNESCO World Heritage program has not changed since 1999; five of the fourteen Australian sites are in Queensland (WHC 2002). All the Queensland sites are listed for their natural heritage values:

- the Wet Tropics area, listed in 1988, stretches along Queensland's north-east coast for some 450 km. It comprises largely tropical rainforests and features an extensive array of rare and threatened animal and plant species;

- the Great Barrier Reef, listed in 1981, holds great scientific interest as the habitat of many threatened species. It is also one of the world's most diverse ecosystems;
- the Central Eastern Rainforests Reserves were listed in 1987. This area straddles the border between New South Wales and Queensland and is listed for its subtropical and temperate rainforests;
- Fraser Island, listed in 1992, is the largest sand island in the world and features remnants of tall rainforest. Half of the world's perched freshwater dune lakes are found on the island inland from the beach; and
- the Riversleigh Australian Fossil Mammal Site was listed in 1994 in conjunction with the Naracoorte Australian Fossil Mammal Site in South Australia (see 'Riversleigh Australian Fossil Mammal Site').

The Register of the National Estate

The Australian Heritage Commission (a part of Environment Australia) maintains the Register of the National Estate (RNE), which includes places of Indigenous, historical and natural heritage value. Part of the registration process involves an assessment of the significance of places against set criteria. The RNE provides the most comprehensive data source for Indigenous places that have been assessed for their cultural heritage significance.

The proportion of Queensland natural, historical and Indigenous place types in the RNE has remained relatively constant over the past four years. At June 2002, 320 natural heritage sites and another 9 interim sites were listed under the *Australian Heritage Commission Act 1975* (table 9.1). Sixteen places of natural heritage value have been added since 1998. Natural heritage places constitute 27% of all places registered in Queensland (figure 9.1). While there is an overlap with sites protected under Queensland's *Nature Conservation Act 1992*, there is not a clear relationship between the two regimes.



Dent Island Lightstation, Whitsundays, constructed in 1879 by the Queensland Government, is listed on both the Queensland Heritage Register and the Register of the National Estate. (Photo: EPA)

Table 9.1 Natural heritage places in Queensland listed in the Register of the National Estate, 30 June 2002

Type of place	No. of Qld sites
Vegetation communities	68
Landform sites and areas	40
Coastal environments	32
Fauna habitats	32
Subtropical environments	28
Tropical environments	27
Flora species sites and habitats	26
Geological sites and areas	22
Wetlands and rivers	20
Island environments	17
Palaeontological sites	8
Marine environments	4
Arid environments	3
Wilderness	2
Total	**329**

Source: AHC 2002a

A total of 899 Queensland places were inscribed in the RNE at 30 June 2002 for their cultural heritage values. Of these, 742 were registered for their historical values and 157 for their Indigenous values (figure 9.1). Few places have been added to the RNE since 1999. The seven added for their historical values represent an increase of less than 1% for that category, while the six Indigenous places added represent a 5% increase in Indigenous entries from Queensland.

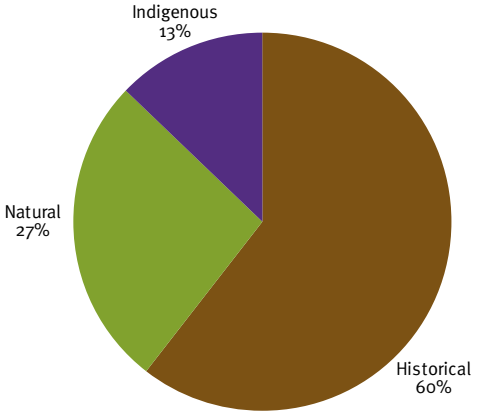


Figure 9.1 *Proportion of places in the Register of the National Estate by value of place, 30 June 2002. Figures include permanent, provisional and interim listings. Source: EA*

The Queensland Heritage Register

The Environmental Protection Agency (EPA) maintains records of historical heritage places throughout Queensland. The Queensland Heritage Register commenced with the enactment of the *Queensland Heritage Act 1992* (Heritage Act). Since 1992, 1888 places have been nominated for entry in the Register.

At 30 June 2002, 1332 places in Queensland were permanently or provisionally entered in the Register. Since 30 June 1998, a total of 279 places have been either permanently or provisionally entered, up from the 129 places entered in the period 1994–97 (figure 9.2).

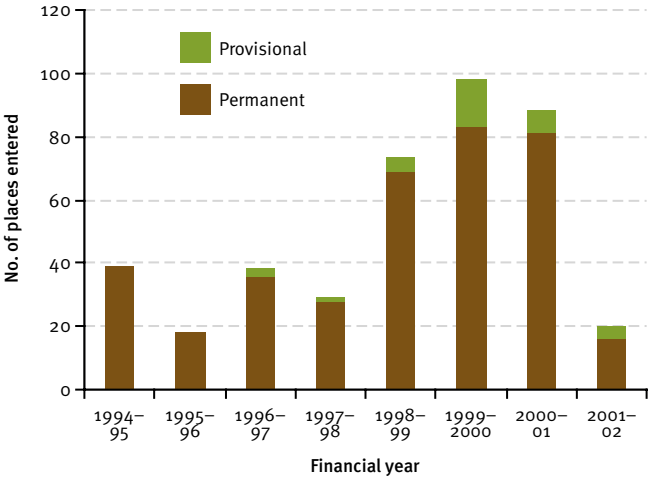


Figure 9.2 *Number of places permanently or provisionally entered in the Queensland Heritage Register, 1994–2001*
Source: EPA

A large number of heritage-registered places are concentrated in highly developed coastal areas. The Brisbane City area has the highest number of places of all local governments (figure 9.3). Major regional centres and major centres in south-east Queensland are also well represented (table 9.2).

Table 9.2 Local government areas with more than 2% of total entries in the Queensland Heritage Register, 30 June 2002

LGA	Permanent	Provisional	Total	Percentage of total places on Register
Brisbane City Council	415	12	427	32.1
Townsville City Council	69	3	72	5.4
Ipswich City Council	71	0	71	5.3
Toowoomba City Council	60	2	62	4.7
Rockhampton City Council	55	3	58	4.4
Warwick Shire Council	45	1	46	3.5
Maryborough City Council	34	0	34	2.6
Isis Shire Council	28	0	28	2.1
Cairns City Council	26	1	27	2.0
Total	**803**	**22**	**825**	**62.0**

Source: EPA

The distribution highlights the fact that many nominations of places for entry in the Register are made in response to threats from development (figure 9.4).

Case study: Riversleigh Australian Fossil Mammal Site

The Riversleigh Australian Fossil Mammal Site in north-west Queensland was included on the World Heritage List in 1994 in conjunction with the Naracoorte Australian Fossil Mammal Site in South Australia. Riversleigh is owned by the State of Queensland and was gazetted as part of Lawn Hill National Park under the *Queensland National Parks and Wildlife Act 1975* in 1984. The landscape at Riversleigh features a large number of visible archaeological traces of Aboriginal occupation and sites of cultural significance. However, the site is listed solely for its natural heritage values.

Examination of faunal assemblages found at Riversleigh has helped scientists better understand Australia's mid-Cainozoic (the period from 65 million years ago to the present) vertebrate diversity, because the remains of 15-million-year-old mammal species have been identified. Several thylacine (*Thylacinus cynocephalus*) specimens have been found in the assemblages. (This animal is also known as the Tasmanian Tiger.) Other ancestral marsupial forms include bandicoots, moles, marsupial 'lions', wombats, kangaroos, koalas and possums. The 35 bat species found in the Riversleigh fossil record mean that the site is considered one of the richest of its type in the world.

Riversleigh is significant because of its representativeness of key stages in the development of Australia's mammal fauna, exemplified by the extreme diversity and/or quality of the preserved materials. The site is also significant in that it represents links with modern biota including the biota of other World Heritage-listed areas in Queensland.
Source: UNEP-WCMC 2002



Excavating a fossil thighbone at Riversleigh (Photo: PROBE Tourism Design, Planning and Management Pty Ltd)

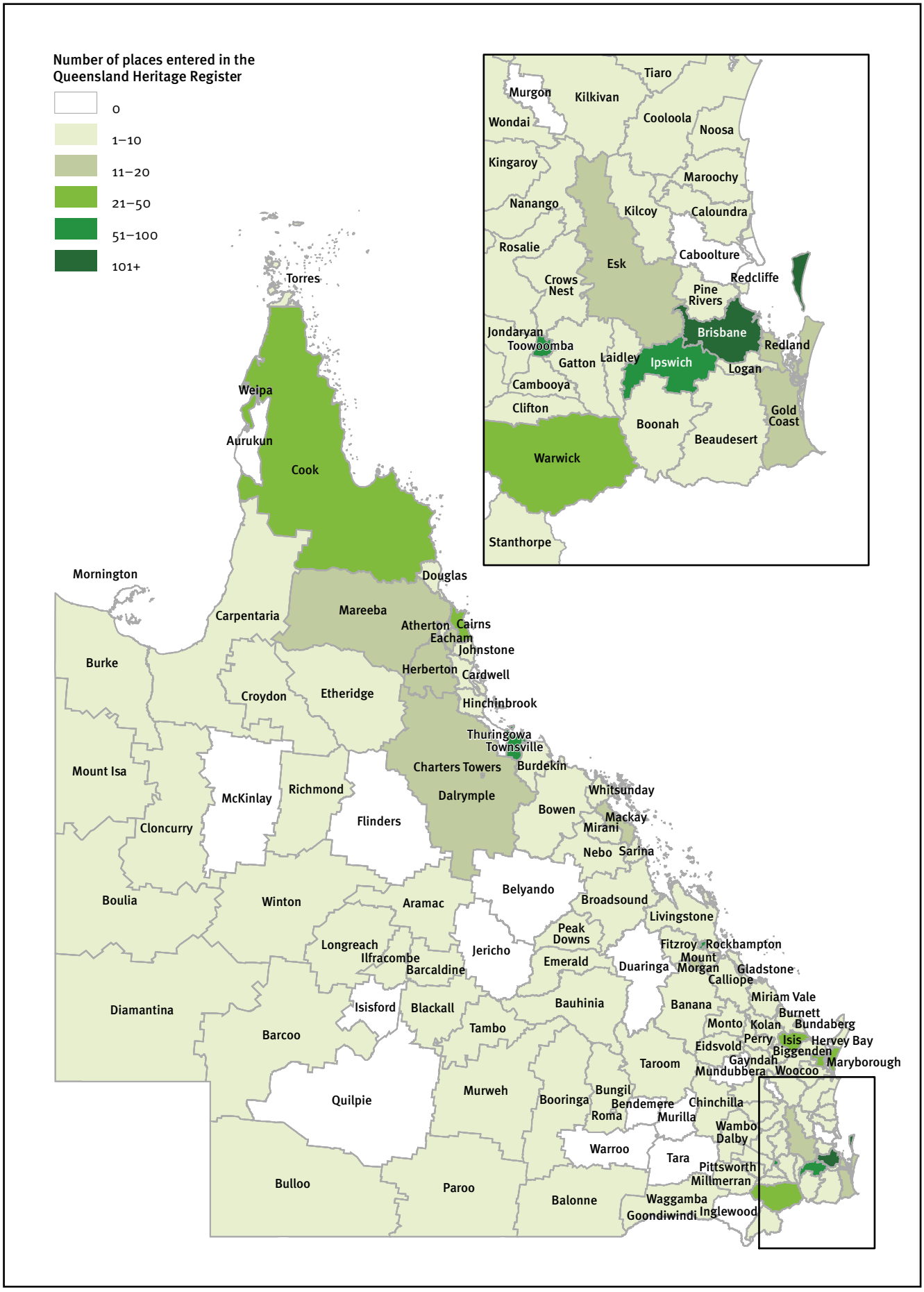


Figure 9.3 *Distribution of places entered in the Queensland Heritage Register by local government area, 30 June 2002*
Source: EPA

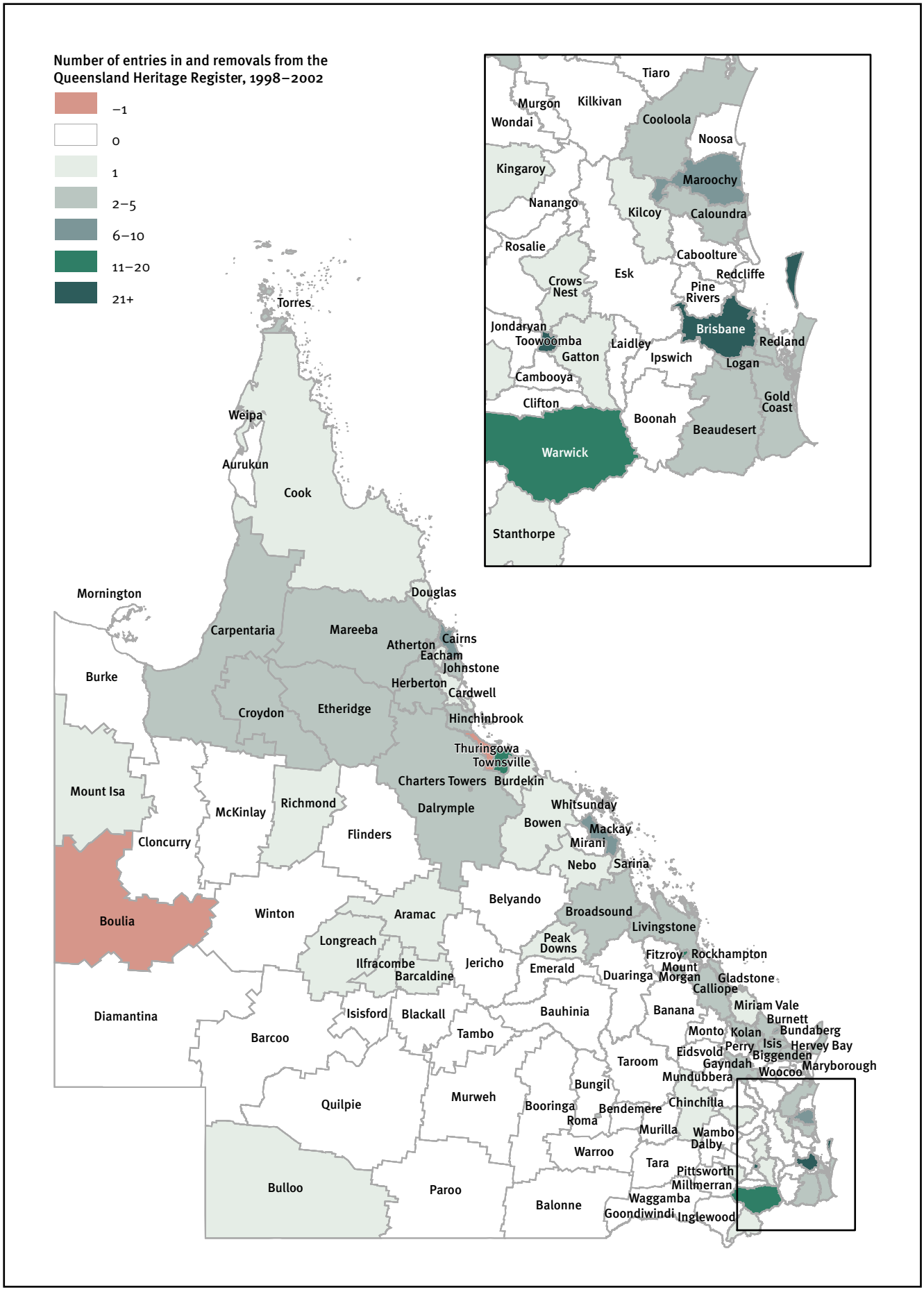


Figure 9.4 *Changes to the number of places in the Queensland Heritage Register by local government area since 1999*
Source: EPA

The number of places entered in the Register since its inception has increased at an average of 4.3% a year (figure 9.5). The period 1998–2001 saw an annual increase of 7.6%, due largely to significant work having been completed on a backlog of nominations between 1998 and 2000 (see 'Responses', page 9.14).

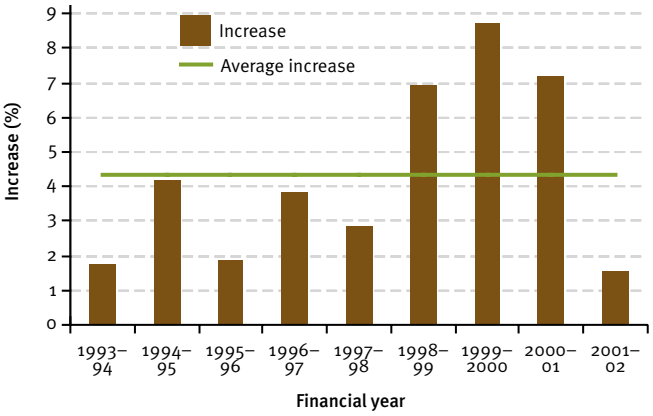


Figure 9.5 *Percentage increase in number of places entered in the Queensland Heritage Register, 1993–2001*
Source: EPA

Places entered in the Register meet one or more of the specific significance criteria set out in the Heritage Act (table 9.3). Figure 9.6 shows the percentages of entries in the Register for each significance criterion. A common public misconception is the belief that a place is entered in the Register because of its aesthetic values. As figure 9.6 shows, however, less than 20% of all entries are made for this reason.

Table 9.3 Criteria for entry in the Queensland Heritage Register, specified in section 23(1) of the *Queensland Heritage Act 1992*

Criterion label	Criterion as specified in the Act
(a)	the place is important in demonstrating the evolution or pattern of Queensland's history
(b)	the place demonstrates rare, uncommon or endangered aspects of Queensland's cultural heritage
(c)	the place has potential to yield information that will contribute to an understanding of Queensland's history
(d)	the place is important in demonstrating the principal characteristics of a particular class of cultural places
(e)	the place is important because of its aesthetic significance
(f)	the place is important in demonstrating a high degree of creative or technical achievement at a particular period
(g)	the place has a strong or special association with a particular community or cultural group for social, cultural or spiritual reasons
(h)	the place has a special association with the life or work of a particular person, group or organisation of importance in Queensland's history



Tieri War Memorial, Tieri, constructed in 1984 as a memorial to servicemen and servicewomen from the Peak Downs area, particularly those serving in the Vietnam War (Photo: EPA)

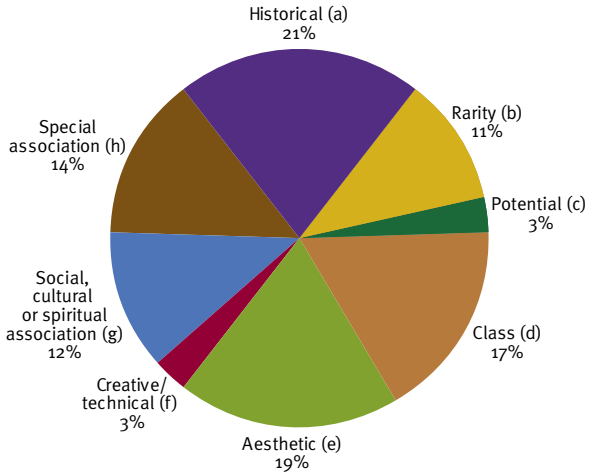


Figure 9.6 *Proportions of entries in the Queensland Heritage Register for each significance criterion, 30 June 2002. For criteria, see table 9.3.*
Source: EPA

Heritage-registered places can also be categorised as a single place type, normally determined by their purpose or use. Table 9.4 shows the number of each type of historical heritage place in the Register at 30 June 2002.

Table 9.4 Number of each type of historical heritage place in the Queensland Heritage Register, 30 June 2002

Place type	No. of places	Percentage of total entries
Commercial	238	18.0
Residential	236	17.8
Religious	130	9.8
Memorial/cemetery	112	8.5
Transport	95	7.2
Education	79	6.0
Pastoral	57	4.3
Law/order	45	3.4
Health	44	3.3
Government—state	33	2.5
Social	32	2.4
Industrial	30	2.3
Mining	30	2.3
Communication	28	2.1
Defence	27	2.0
Government—local	25	1.9
Recreation	25	1.9
Parks/gardens	21	1.6
Farming	16	1.2
Exploration/survey	5	0.4
Political	5	0.4
Settlement	5	0.4
Government—Commonwealth	3	0.2
Scientific	3	0.2
Total	**1324**	**100.0**

Source: EPA



St Lawrence Meatworks, St Lawrence, is an important illustration of early industrial development of Queensland and of the settlement of the Broadsound area in particular. (Photo: EPA)

The 2002 figures cannot be directly compared to the 1999 figures because of changes in data collection methodologies and the use of a new database that only allows for selection of a single place type. However, the proportions of place types in the Register have changed little since 1999. The five most common—commercial, residential, religious, memorials/cemeteries and transport-related—were the most common types reported in 1999 (EPA 1999a).

Places that may not necessarily have been nominated for entry in the Register have also been identified in other historical heritage studies. A total of 6035 historical heritage places have been reported to the EPA in this manner. This information is stored mainly in the Queensland Cultural Heritage Inventory of Places—Historic Inventory database, maintained by the EPA's Cultural Heritage Branch. The number of places that have been added to this inventory since 1999 is not known, though it is probably very low. Historical places not entered in the Register are currently protected under the *Cultural Record (Landscapes Queensland and Queensland Estate) Act 1987* (Cultural Record Act).



The wreck of the Maheno *in the World Heritage Area of Fraser Island. The ship was washed ashore during a cyclone in 1935. (Photo: S. Murphy)*

Queensland shipwrecks

All shipwrecks more than 75 years old in Commonwealth waters are protected under the Commonwealth *Historic Shipwrecks Act 1976*. Wrecks are listed in the Register of Historic Shipwrecks. The Queensland Museum is responsible for the maintenance of this register in Queensland. The register currently contains 1056 shipwrecks dating from 1790 to 1945 (847 shipwrecks were listed in the register in 1999). Of these, 1043 are protected under Commonwealth legislation. While ships wrecked within Queensland's territorial waters can be protected under the Heritage Act, no list or register of such shipwrecks is maintained under the Act. The locations of only 71 shipwrecks (7%) in the Queensland Museum's register have been verified. This number is up from the 48 positive locations reported in 1999. Significance assessments have been conducted on 32 of the 71 known wreck sites. Figure 9.7 shows the locations of some of these wrecks.

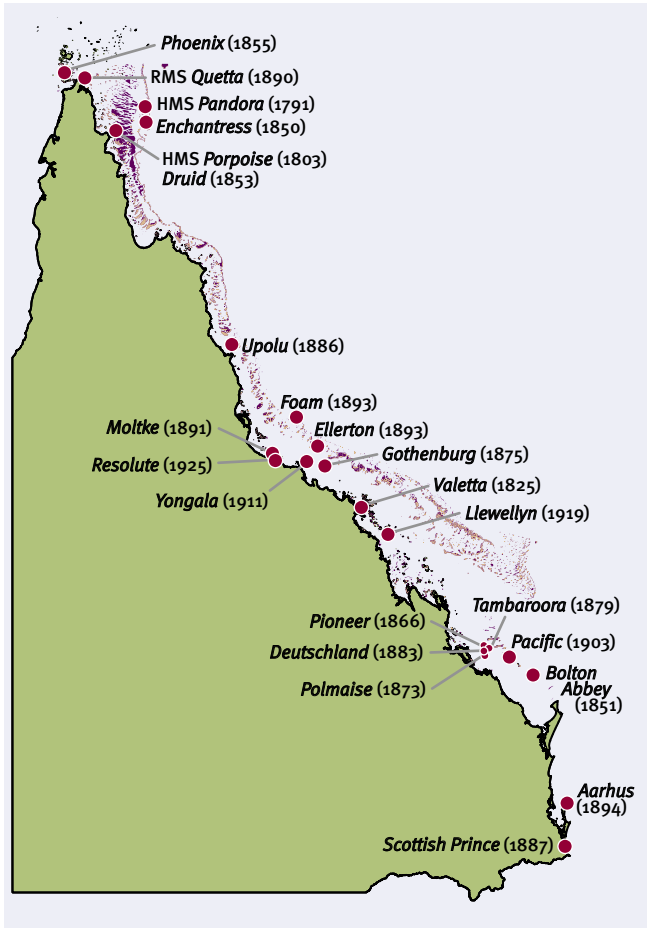


Figure 9.7 *Known locations of some of Queensland's historic shipwrecks that have been assessed for their significance Source: EPA 2002i*

Indigenous Sites Database

The EPA maintains records of Indigenous heritage places recorded under the provisions of the Cultural Record Act. Designated Landscape Areas (DLAs) are places of cultural heritage significance and are protected under the Act. At 30 June 2002, nine DLAs were declared in Queensland. No new DLAs have been declared since 1999 as no submissions have been made for the declaration of any such areas during the reporting period. The reasons for the absence of submissions remain unclear.

As reported in *Australia State of Environment 2001*, some Indigenous groups and communities remain suspicious of government agencies that maintain registers and lists of Indigenous places, and are concerned about how any information held will be used (ASEC 2001). As a result, some places found during cultural heritage investigations are not reported. It is known that not all cultural heritage survey reports and associated place information are currently being submitted to the EPA. However, a total of 9137 Indigenous heritage places have been added to the Indigenous Sites Database since June 1998, bringing the total number of records to 16 660 at 30 June 2002 (figure 9.8). This represents significant growth from the 7523 records reported in 1999 (EPA 1999a).

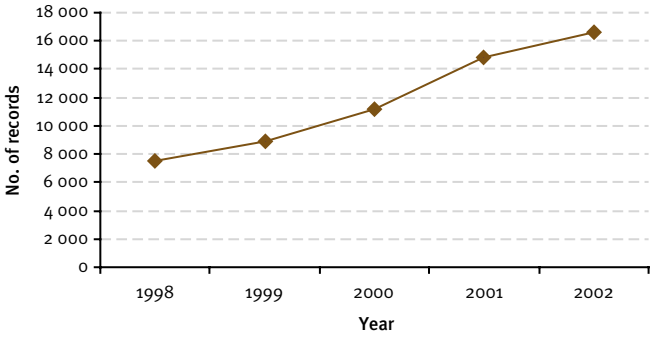


Figure 9.8 *Number of records on the EPA Indigenous Sites Database, June 1998 – June 2002*
Source: EPA

The figures are somewhat misleading, as the vast majority of the records entered were reported to the EPA before 1999, but were not entered into the database in time for analysis. Since June 1998, a total of 4374 new places have been recorded by consultants and researchers, and reported to the EPA. This amounts to an average of 1093 new places each year (table 9.5).

Table 9.5 New Indigenous heritage places reported to the EPA each year, 1998–2002

Year	Number of places
1998–99	1197
1999–2000	1216
2000–01	882
2001–02	1079
Total	**4374**

Source: EPA

There is no formal Register of the Queensland Estate for items and places of 'great significance to Queensland's history' under the Cultural Record Act. Although places entered in the Indigenous Sites Database are not currently assessed for significance as a matter of course, several places have been assessed as part of detailed cultural heritage management planning processes. Examples include The Palace in central Queensland (Godwin 1992; see also 'The Palace art site complex' on page 9.54); the rock art sites of the Laura region in far north Queensland (Sullivan 1992); and Gracevale in central western Queensland (Franklin 1999). See 'Gracevale Rock Art Site', page 9.16.

Information about heritage places recorded on databases should be considered as only a sample of the true distribution and type of Indigenous places throughout the state. Table 9.6 shows the number of each type of place recorded on EPA databases in 1998 and 2002. A large number of artefact scatters, scarred/carved trees, hearths/ovens and middens have been added to the Indigenous Sites Database since 1998. This can be interpreted as a direct result of the majority of surveys in Queensland being conducted, in recent times, in response to development (see 'Development', page 9.19), as these sites are the types most often found during such assessments.

Table 9.6 Number and percentage by category of places entered in the Indigenous Sites Database, 30 June 2002 and 30 June 1998

Type of place	2002	Percentage of records	1998	Percentage of records
Artefact scatters	8 219	38.9	2 482	25.8
Paintings	2 556	12.1	2 195	22.8
Shell middens	2 419	11.5	1 252	13.0
Scarred/carved trees	1 345	6.4	464	4.8
Hearths/ovens	862	4.1	125	1.3
Quarries	679	3.2	221	2.3
Stone arrangements	670	3.2	518	5.4
Burials	520	2.5	359	3.7
Engravings	467	2.2	414	4.3
Grinding grooves	361	1.7	255	2.6
Story places	324	1.5	105	1.1
Weirs/fish traps	176	0.8	59	0.6
Earthen arrangements	170	0.8	83	0.9
Wells	127	0.6	84	0.9
Pathways	87	0.4	34	0.4
Dwellings	75	0.4	46	0.5
Other*	2 062	9.8	930	9.7
Total	**21 119**	**100.0**	**9 626**	**100.0**

*Several categories have been added to the Indigenous Sites Database since 1999. These include 'Landscape feature', 'Cultural site' and 'Contact site'. For comparative purposes, such sites have been grouped here under 'Other', the category in which they would formerly have been placed.

Source: EPA



Indigenous shell midden providing material evidence of human occupation of this site at Fraser Island (Photo: EPA)

Despite increasing pressure from development, less than 10% of Queensland is estimated to have undergone systematic survey for Indigenous heritage places. While many surveys have been conducted since 1999, at November 2002 no systematic overview of the state had been conducted. Figure 9.9 shows the distribution of known Indigenous heritage places throughout Queensland. The majority of recordings made in the past four years have been in the south-east corner of the state, while large areas of northern and western Queensland remain largely unchanged.

There are known biases in the distribution of recorded Indigenous heritage places on the Indigenous Sites Database. Geographic biases have been apparent since the inception of Indigenous place recording in Queensland (Rowland 1989). Place distribution has been interpreted as reflecting the distribution of people involved in cultural heritage recording

and the ease of access to certain areas, rather than providing a real picture of the pattern of Indigenous heritage place locations (Rowland 1989). More recently, Rowland and Connolly (2002) noted that a significant number of recordings have been made in coastal areas, driven by both development and research, though fewer places have been recorded on the coast around Cape York and in the Gulf Country. Rock art research in places such as the Carnarvon region, the Northwest Highlands and around Laura in north Queensland is also skewing distributions (Rowland and Connolly 2002). Increases in the number of sites recorded as a result of urban development in south-east Queensland and the many mining operations in central and north-west Queensland are also apparent in figure 9.9.

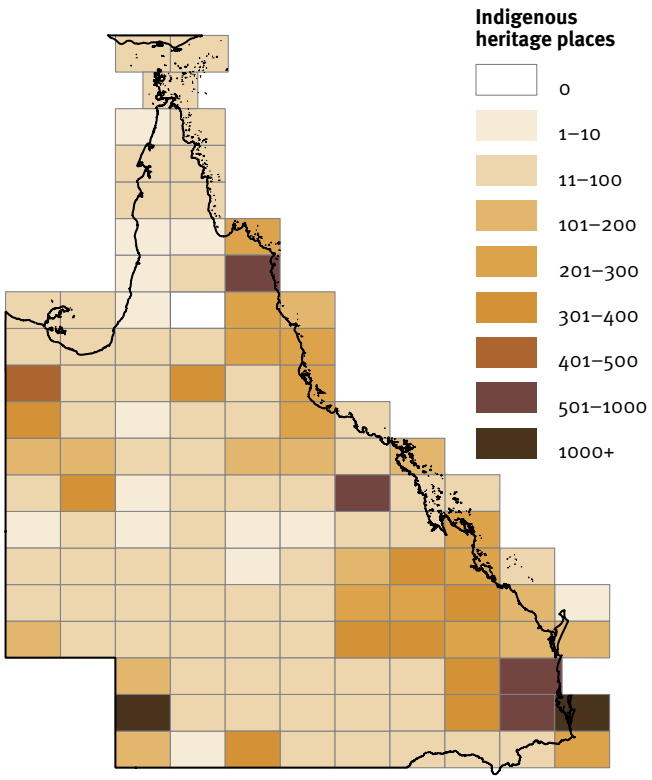


Figure 9.9 *Density of Queensland's Indigenous heritage places reported to the EPA by 1:250 000-scale topographic map sheet Source: EPA*

Local government registers and inventories

In October 2002, the EPA conducted a survey of Queensland's 125 local government authorities (LGAs) concerning cultural heritage provisions of their planning schemes, their employment of cultural heritage personnel, and the nature of any support they provided to local museums, galleries and owners of heritage places. Eighty-eight (70%) of the 125 LGAs responded to the survey. Responses were received from all parts of the state, though there may be some biases in the data, as responses from the north-west and central northern regions were limited (figure 9.10). Not all LGAs that responded to a similar survey conducted in 1999 responded in 2002, making comparisons of results difficult.

Table 9.7 lists the LGAs that maintain registers and inventories of cultural heritage places. Thirty-one LGAs maintain registers of historical heritage places, while 38 maintain a register of places entered in the Queensland Heritage Register. Only ten LGAs maintain registers of Indigenous heritage places, an indication that at a local level, the recognition and protection of Queensland's Indigenous heritage are problematic.

Registers vary widely in size, recording from one to more than 6000 places. The 13 243 historical heritage places listed in local registers at 30 June 2002 included many places also entered in the Queensland Heritage Register. Historical heritage places account for 98% of all places listed in local registers and inventories. The extent of overlap with state and Commonwealth registers and databases remains unknown.

Table 9.7 Local government areas with heritage registers or inventories, and number of places recorded (where provided)

Local government area	Historical	Indigenous
Aramac	1	1
Atherton	5	–
Beaudesert	5	–
Brisbane	937	–
Broadsound	3	–
Burnett	167	–
Cairns	122	18
Caloundra	175	175
Charters Towers	209	–
Clifton	17	–
Cook	49	–
Cooloola	512	–
Croydon	180	5
Diamantina	30	30
Douglas	27	–
Emerald	1	–
Gladstone	112	–
Herberton	260	–
Hervey Bay	5	6
Ipswich	6 880	17
Isisford	–	–
Jondaryan	5	–
Kilkivan	–	–
Kingaroy	150	1
Livingstone	21	35
Longreach	4	–
Mackay	60	–
Maroochy	–	–
Millmerran	–	–
Murilla	8	–
Nanango	4	–
Noosa	182	–
Pine Rivers	–	–
Pittsworth	1	–
Redcliffe	2	–
Redland	109	–
Roma	18	–
Sarina	2	–
Thuringowa	131	–
Toowoomba	2 000	–
Townsville	500	5
Warwick	331	–
Wondai	18	–
Total	**13 243**	**293**

Source: EPA 2002j

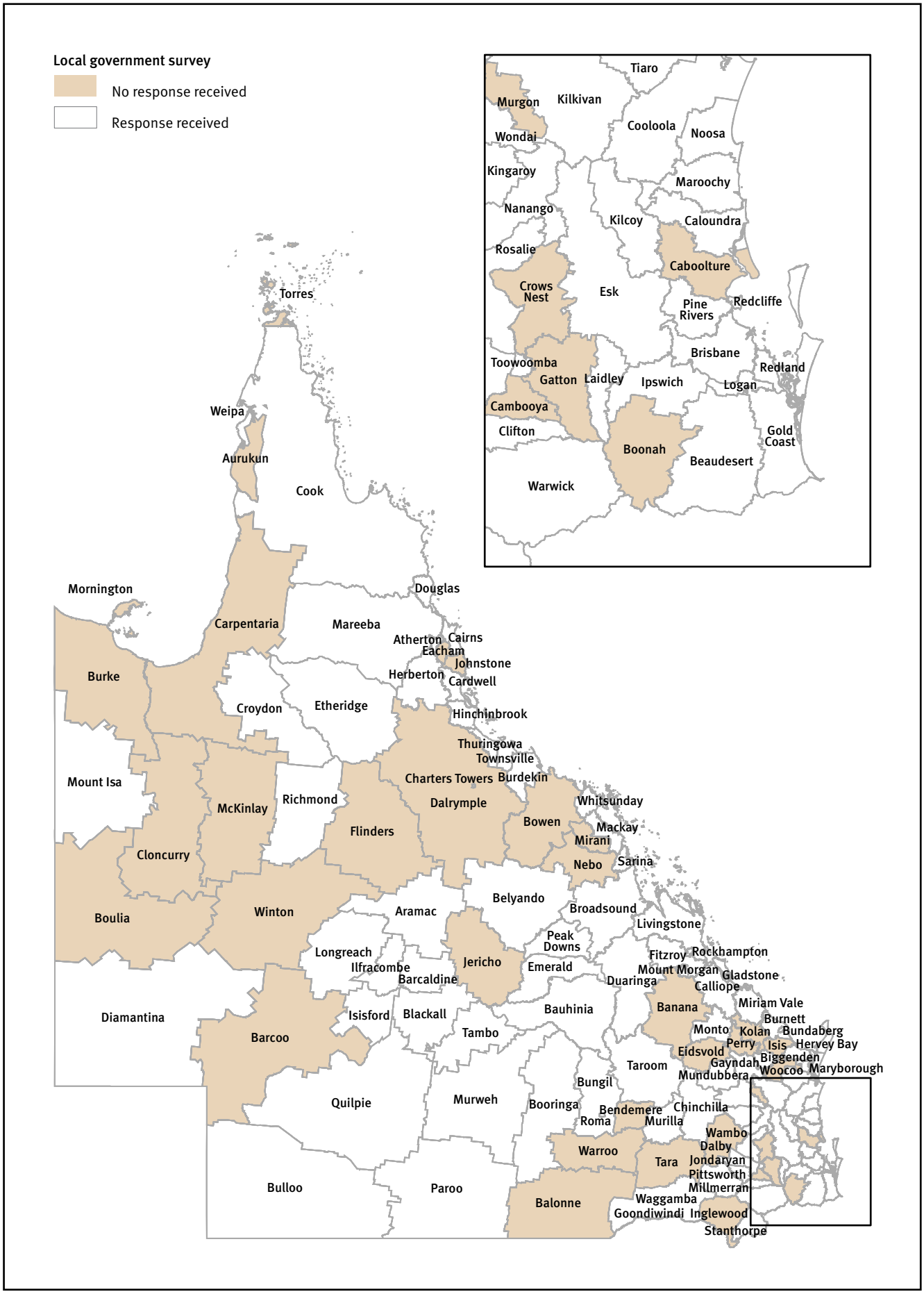


Figure 9.10 *Distribution of respondent LGAs to heritage survey conducted for this report*
Source: EPA 2002j



Natural and cultural heritage on display at the Queensland Museum, South Bank, South Brisbane (Photo: Tourism Queensland)

Cultural heritage collections

The directory of Museums Australia (Queensland) (MAQ) lists 363 museums in Queensland (MAQ 2001). In 1999, the figure of 'more than 200 museums' was the best estimate available (EPA 1999a). Table 9.8 shows how MAQ classifies the museums.

Table 9.8 Numbers of types of museums as classified by MAQ

Type of museum or gallery*	Number
Museum	252
Historical society	146
Historic property	100
Touring venue	65
Art gallery	64
Genealogical society	16
Heritage park	13
Indigenous keeping place	7
Art society	2

*Individual collecting institutions may be listed under more than one category.

Source: MAQ 2001

The Regional Galleries Association of Queensland (RGAQ) lists some 64 regional galleries on its Regional Galleries Network (RGAQ 2002), which divides the state into 13 areas. There is, however, considerable overlap between RGAQ and MAQ's listings, 54 of the 64 regional galleries also being listed on MAQ's directory. The difficulty of defining the scope of a museum and differences in the nature of museums noted in 1999 (EPA 1999a) is apparent in the listings provided by RGAQ and MAQ. Many museums and galleries also serve other functions, as cultural centres, libraries, theatres, visitor centres, community centres, shire council offices and convention centres.

In October 2002 the EPA surveyed four major collecting institutions in Queensland: the Queensland Museum and campuses, the John Oxley Library, the Queensland State Archives and the Queensland Art Gallery. Table 9.9 shows the size of these institutions' collections. There was gradual growth in the numbers of items in these collecting institutions from 1996–97 to 2001–02. The John Oxley Library experienced the most dramatic increase in the number of items in its collection in 1998–99 (80%) and 1999–2000 (63%). Since 1999, the level of accessioning and documentation of cultural heritage collections has either improved or remained the same. The Queensland Museum acknowledges, however, that there is a backlog in the accessioning of items into its collections, as is apparent from the numbers of items that have not been accessioned (table 9.10). The reasons cited by collecting institutions for the backlog in accessioning are a lack of resources and past inexperience in appraisal, the labour- and time-intensive nature of the work, and the diversion of staff time to community consultation and public product outcomes. Both the Queensland Museum and the John Oxley Library have been successful in reducing the size of their undocumented collections since 1999, when 15% of the Queensland Museum's collections were undocumented, as were 50% of the John Oxley Library holdings. The figures from the Queensland Museum also show good progress in the proportion of items catalogued on computer systems (93%, compared with only 57% in 1999).

Table 9.9 Number of items in cultural heritage collections in major collecting institutions in Queensland

Financial year	Queensland Museum[a]	Museum of Lands, Mapping and Surveying[b]	John Oxley Library[c]	Queensland State Archives[d]	Queensland Art Gallery
1996–97	100 639	300–400	704 445	32 325	10 277
1997–98	105 586	n/a	707 628	33 236	10 500
1998–99	110 104	n/a	1 273 051	33 771	10 720
1999–2000	119 290	n/a	2 080 519	34 068	11 000
2000–01	121 088	n/a	2 085 576	34 550	11 093
2001–02	123 551	1000	2 091 564	35 670	11 303

[a]The figures for the Queensland Museum have been adjusted and do not include multiple items under single entries for archaeological collections, which in 1996 were estimated at 350 000 items. These figures are therefore not comparable with those quoted in 1999 (EPA 1999a). The figures presented for the Queensland Museum also include the collections of the Cobb & Co. Museum.
[b]The Museum of Lands, Mapping and Surveying is a campus of the Queensland Museum but data have been collected separately.
[c]These figures do not include manuscripts, which are measured in linear metres.
[d]These figures are a linear measurement of records stored on standard shelving. It does not include figures on special storage, such as the microfilm vault or plans and drawings storage.
n/a = not available

Source: EPA 2002i

Table 9.10 State of knowledge about Queensland cultural heritage collections, as measured by the number of items collected, and the extent to which they are accessioned, documented and catalogued on computer

Collecting institution	Number/ extent of items	% of items accessioned	% catalogued on computer	% well documented	% partially documented	% undocumented
Queensland Museum	123 551	91	93	29	61	10
Museum of Lands, Mapping and Surveying	1000 (surveying and mapping equipment); 800 (photographs)	100 (on card index)	<1 (objects) 100 (photographs)	50	50	0
John Oxley Library	2 091 564	100	100 (does not include photographs)	30	60	10
Queensland State Archives	35 670	95	100	90 (relates to number of series approved in system)	10	0
Queensland Art Gallery	11 303	100	100	59	41	0

Source: EPA 2002i

A qualitative review of small and regional museums and galleries in Queensland in 2000 for the report *Australia State of the Environment 2001* found that very few museums conducted adequate cataloguing and that many local museums did not consider cataloguing to be a key task (Pearson et al. 2001). By contrast, the majority of galleries had complete catalogues of their works, some with electronic databases, hard copy catalogues and images. Others had inventory lists that were only partially completed.

Responses

Natural heritage places

Since 1999, knowledge of regional, ecosystem, species and genetic diversity has grown as a result of research programs conducted by a range of institutions, including universities, the Queensland Museum, Commonwealth Scientific and Industrial Research Organisation (CSIRO), Queensland Parks and Wildlife Service (QPWS), Great Barrier Reef Marine Park Authority (GBRMPA) and Wet Tropics Management Authority (WTMA), and joint studies through various cooperative research centres. The use of satellite imagery and aerial photography is yielding new information about both the character of and changes in land cover and canopy. Studies in habitat and species interactions are providing more information about Queensland's natural environment. Details appear in other chapters of this report. The major change in protective measures since 1999 has been a significant increase in the number of nature refuges (table 9.11).

Table 9.11 Number and extent of protected areas in Queensland and changes since 30 June 1999

Protected area category	Number at 30 June 2002	Change in number since 1999	Total area (ha) at 30 June 2002	Increase in area (ha) since 1999
National park	212*	–3	6 649 058	36 516
Conservation park	173	+13	36 776	7 554
Nature refuge	73	+36	33 209	21 110
Resources reserve	39	0	352 191	985
National park (scientific)	7	0	52 181	0
Coordinated conservation area	1	0	1 170	0
Total	**505**	**+46**	**7 124 585**	**66 580**

*Number has fallen since 1999 due to the amalgamation of several parks.

Sources: EPA 1999a, 2002b

As prehistoric sites at Riversleigh have achieved World Heritage status, other finds of dinosaur remains have sparked a wave of public interest. Lark Quarry, where dinosaur footprints provide evidence of a dinosaur stampede, has been recognised for its heritage significance. The area is designated as a conservation park, and infrastructure has been built to protect the remains. The remains of a prehistoric Plesiosaur (a marine reptile) found in a remote part of the Gulf of Carpentaria region in 1999 are also yielding valuable information about prehistoric biology. Volunteers participated in the excavation of the fossil remains of a Sauropod dinosaur nicknamed 'Elliot' in western Queensland during 2002. These remains are on private land.

Cultural heritage places

As mentioned earlier, some Indigenous groups and communities have reservations concerning the management by government authorities of information concerning their heritage. Access to information held by the EPA is available on a case-by-case basis; detailed information is provided only after the relevant Traditional Owners have been consulted and have given their approval.

Cultural heritage professionals, researchers, Indigenous communities and native title claimants, LGAs, other state government departments and developers are applying increasing pressure on the EPA for reliable and accurate information pertaining to Indigenous heritage issues.

A project to streamline Indigenous data management processes was initiated in 2000, with an intensive update of the database for the recording of Indigenous heritage places reported to the EPA (Harvey 2002). The types of places recorded are still predominantly of an archaeological nature, but the database now includes provisions for the recording of places for their non-physical values.

The implementation of the *Integrated Planning Act 1997* has resulted in a number of local governments incorporating cultural heritage provisions into planning processes. While no systematic surveys have been conducted at a statewide level, several local governments report that comprehensive surveys have been or are being conducted at the local government level. Forty-five percent of respondents to the questionnaire that was sent to all local governments for this report have conducted surveys for historical cultural heritage. However, only 16 shires have conducted Indigenous cultural heritage surveys. The majority of cultural heritage surveys reportedly cover 75–100% of the LGA (table 9.12). Thirty-two percent of respondents have integrated the findings of their historical cultural heritage surveys into planning schemes, while only 16% have incorporated findings from Indigenous cultural heritage surveys.

Table 9.12 Proportion of local government area surveyed for historical and Indigenous cultural heritage

	Historical heritage		Indigenous heritage	
Percentage of LGA surveyed	**No. of LGAs**	**Percentage of all LGAs surveyed**	**No. of LGAs**	**Percentage of all LGAs surveyed**
1–24	7	18.9	2	12.5
25–49	1	2.7	1	6.3
50–74	3	8.1	0	0.0
75–100	25	67.5	12	75.0
No response	1	2.7	1	6.3
Total	**37**	**100.0**	**16**	**100.0**

Source: EPA 2002j

Specific projects undertaken by the EPA between 1998 and 2000 resulted in a high number of historical places being reported to the EPA and/or added to the Queensland Heritage Register. Projects targeted topics such as Queensland's mining heritage places and historical places located in forested areas. Figure 9.11 shows the number of places reported to the EPA and nominated for entry in the Queensland Heritage Register, and places recorded by the EPA during specific forestry studies.

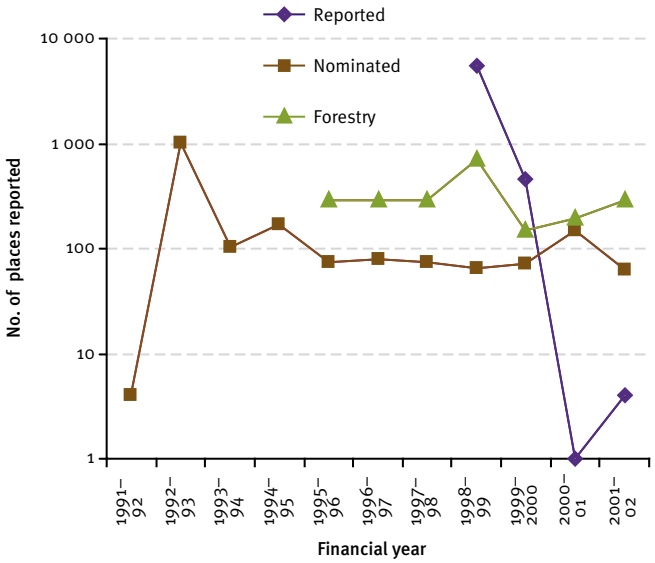


Figure 9.11 *Historical heritage places reported to and recorded by the EPA each year, 1991–92 to 2001–02*
Source: EPA

Non-Indigenous heritage surveys of forested areas within the Southeast Queensland bioregion began in 1995 as part of the South East Queensland Regional Forest Agreement (SEQRFA) (EPA 2002a). An inventory of 830 historical places was established and the results were entered in the EPA Cultural Heritage and Information on the Environment and Forests database. Follow-up work in the Southern Brigalow Belt was undertaken between 1998 and 2002.

Recently, Queensland's commitment to the Montreal Process for Sustainable Forest Management has seen additional funding allocated for the collection of non-Indigenous heritage data from several state forest areas in Central Queensland (EPA 2002a). At March 2003, 2214 places had been located in surveys across 3.9 million hectares of state forest and 7 million hectares of protected area estate.

Since 1999, forest management staff from the Department of Natural Resources and Mines and QPWS have conducted non-Indigenous cultural heritage inventory survey projects in many public forest areas. These include the Mackay Highlands, Barakula, Inglewood, Yuleba, Roma, Injune, Springsure, Clermont, Rockhampton, Duaringa, the Blackdown Tableland, the Atherton Tableland and Paluma.

Collections

Rapid growth in collections can have an adverse impact on their state, particularly where storage space is limited (EPA 1999a). Table 9.13 shows the available storage space for Queensland's major collecting institutions.

Table 9.13 Available storage space at Queensland collecting institutions, 30 June 2002

Collecting institution	Available storage space (m^2)	Available storage space (m)*
Queensland Museum	4 457	n/a
Museum of Lands, Mapping and Surveying	72	n/a
John Oxley Library	531	n/a
Queensland State Archives*	n/a	43 596
Queensland Art Gallery	1 875	n/a

*These figures are a linear measurement of records stored on standard shelving.
n/a = not available

Source: EPA 2002i

Most of the major collecting institutions surveyed indicated that their present storage space is adequate or that they are dealing with any shortages that currently exist. For example, the $260 million Millennium Arts Project will create a new Queensland Gallery of Modern Art, enabling the Queensland Art Gallery's collection to be split between the two buildings (DPC 2002; EPA 2002i). Similarly, the development of a new off-site storage facility for the Queensland Museum at Hendra in July 2002 has reduced the pressure on the museum's South Bank store. Although it is not known for how long this new storage space will be adequate, current collection development and de-accessioning policies are to be reviewed as part of a recent restructure of the Queensland Museum.

Summary of condition and trend indicators

Knowledge of Queensland's heritage

Indicator	Queensland
Number of heritage places identified and recorded in Queensland and Commonwealth heritage inventories	▲
Number, size and distribution of Queensland's protected areas	▲
Number of places in Queensland on World Heritage lists	–
Distribution of heritage places identified and recorded in Queensland or Commonwealth heritage inventories	▼
Number of heritage places reported to and recorded by the EPA per year	–
Land area surveyed for heritage places	▲
Number of each type of heritage place recorded	▼
Number of heritage places recorded that have been assessed for heritage significance	▲
Number of museums and collecting institutions in Queensland	▲
Range of types of museums in Queensland	–
Number of items in heritage collections	▲
Proportion of collections accessioned or documented, including proportion catalogued on computer	▲
Rate of collection growth in Queensland's collecting institutions	▼
Storage space available for collection growth in Queensland's collecting institutions	?

Key to condition:

Good

Moderate

Poor

Not assessed

Key to trend:

▼ Decreasing
▲ Increasing
? Not clear
X Not assessed
– No change

Case study: Gracevale Rock Art Site

Gracevale Rock Art Site is located on Gracevale Station, east of Aramac in central western Queensland. The site comprises a large and extensively weathered sandstone rock shelter featuring engraved and stencilled rock art. In response to pressures from increasing visitation by tourists, the EPA developed management guidelines for the site.

An assessment of significance was undertaken as part of the development of these guidelines. The site has contemporary, traditional, historical and aesthetic significance to the Traditional Owners and custodians of country. It is significant for its potential to contribute to future rock art research in the region and to educate the wider public about Aboriginal culture. It is also important for its potential to foster joint management relationships between government and relevant Traditional Owner groups.

The management guidelines provide recommendations for further research, recording and survey of the area, implementing monitoring programs, upgrading infrastructure including tracks, fencing and a visitor book, and developing an interpretive program. These guidelines will help to provide for the conservation of all elements of significance at the site.

Source: Franklin 1999



Engravings at the Gracevale Rock Art site (Photo: EPA)



Members of the Traditional Owner groups view the engravings being protected under the management guidelines at the Gracevale Rock Art Site, near Aramac, central western Queensland (Photo: EPA)

Case study: Childers Backpackers

On the night of 22 June 2000, a fire at the Palace Backpackers Hostel in Childers claimed the lives of 15 young travellers. Overnight, the place became internationally significant, although much of the heritage-registered building was destroyed.

The former Palace Hotel was constructed at the centre of the main street of Childers in about 1902, after a fire destroyed the first timber Palace Hotel and many adjoining buildings. The new hotel, built in brick, was the centre of public life in the town for many years, until its licence was transferred in the 1980s.

After the fire in 2000, it was proposed that the Palace be reconstructed as it had first been built as a memorial to those who had died. There were, however, practical impediments to this approach. There was also debate about the integration of the surviving parts of the old building with the new facilities and materials, amid fears that extensive reconstruction might hide the impact of the fire.

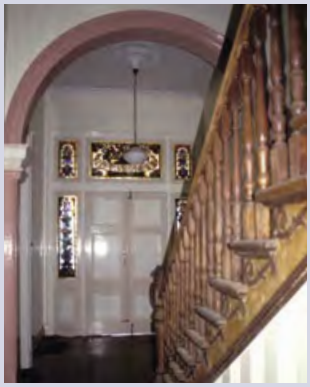
The Palace Memorial Building was opened in October 2002. The first floor of the main building, which had formerly provided accommodation, is now a contemporary gallery space with the memorial installations at one end. The ground floor is an interpretation of the former spaces, using surviving building finishes and copies of those destroyed, and early colour schemes. The form of the rear wings, which were largely destroyed in the fire, has been interpreted in the layout of a memorial courtyard.

The project to conserve the significance of the Palace went far beyond the retention of surviving joinery and reconstruction of destroyed rooms. It included conserving the Palace's significance through the celebration of the lives lost in the fire, through re-establishing it as a vibrant focal point in the social life and streetscape of Childers, and through interpreting the stories of the place's life.

Source: Armstrong 2002



The Palace Hotel, Childers, about 1928 (Photo: John Oxley Library)





The entry hall and stairs of the Palace Hotel, June 1993 (left) and 28 June 2000 (right) (Photos: EPA)

Case study: Life on board the 18th-century sailing vessel HMS *Pandora*

HMS *Pandora* was wrecked in what is now known as Pandora Entrance on the Great Barrier Reef on 24 August 1791, after sailing from England in a bid to capture the mutineers from the infamous HMS *Bounty*. A 24-gun, sixth-rate frigate, *Pandora* was built in England in 1779. *Pandora* is perhaps the most important shipwreck currently known off the east coast of Australia. Her remains offer a snapshot of life on board an 18th-century sailing vessel and have historical, archaeological and social values of international significance. Responsibility for preservation and conservation lies with the Maritime Archaeology section of the Queensland Museum, which conducts regular expeditions to the wreck. Artefacts recovered from the wreck site include cannon, the ship's anchor and small items such as stoneware jars, glassware and personal items. Items retrieved from the *Pandora* now form a major exhibition at the Museum of Tropical Queensland, Townsville.

Source: MTQ 2002



A replica of the Pandora *forms part of the exhibition in the Museum of Tropical Queensland, Townsville, displaying the heritage of the shipwreck found off the coast of Queensland. (Photo: Tourism Queensland)*

Assessing the condition of Queensland's heritage

Summary

There is no standard measure for monitoring the physical condition of Indigenous heritage places in Queensland. The only data available are from site recordings made to the EPA, which reported condition at the time of recording. Collecting data on the condition of historical heritage places is difficult, complex and expensive. There are no current data on the condition of places entered in the Queensland Heritage Register. There is no consistent or comprehensive approach to assessing the condition of protected areas or other places of natural heritage. Only limited conservation surveys of heritage collections have been undertaken, and conservation treatment has been limited.

In Queensland, the greatest numbers of people speaking an Indigenous language are in the far north. The condition of Indigenous languages in the state is precarious: a small number of languages remain strong and steady; some are strong, but transmission to younger speakers is declining; and some are threatened. Limited data are available on languages identified in 1990 as being severely threatened (EPA 1999a). A detailed survey of Indigenous languages and further research are necessary to accurately assess and improve their condition. Various organisations and communities are initiating projects to document local Indigenous languages, but it is uncertain what effect this documentation is having.

Development places a major pressure on the condition of Indigenous and historical heritage places. Major pressures on the condition of all heritage places include lack of awareness, negative attitudes towards and perceptions about heritage and heritage places, and numbers of visitors to heritage places for tourism and recreation in the absence of appropriate management infrastructure. Socioeconomic factors, such as population shift, change in industrial and rural use patterns, and under-resourcing place pressures on the condition of heritage places. The pressure of inappropriate environmental conditions for storage of heritage collections is greater in small and regional museums than in large collecting institutions and regional galleries.

The overriding pressure on heritage, particularly heritage places and collections, however, is the lack of information. Without information, it is currently not possible to assess the condition of Queensland's heritage. The deficiency in the level of support for heritage programs in Queensland (see 'Protecting Queensland's heritage', page 9.32) is unlikely to change while there is no information to confirm the level of damage that is occurring, and the consequent level of need for funding. This lack of information about the condition of heritage in Queensland is a significant weakness in the overall system of heritage management in this state.

Description

The physical condition of Indigenous, historical and natural heritage places and heritage collections in Queensland is assessed below. The state of Indigenous languages in Queensland, the number of speakers and the level of documentation are also discussed. Although assessment of the condition of heritage is difficult, the identification and management of pressures are important in the management and maintenance of our cultural and natural heritage resources.

A number of indicators that were not considered in 1999 are reported on in relation to this issue. These include the number of Indigenous and historical heritage places assessed for condition or damage caused by human activity. The indicator related to the issuing of permits has been broadened since 1999; it considers all types of permits issued under cultural heritage legislation, including permits to survey for, excavate and collect cultural heritage, to enter a designated landscape area, and to explore and recover historic shipwrecks and relics. Indicators on natural heritage places are also new, as a result of the expanded theme for the chapter. A new indicator for heritage collections goes beyond consideration of the proportion of collections surveyed by trained conservators to assess the proportion of collections that have had conservation treatment. New indicators are also included for the number, distribution and age of Indigenous language speakers and the level of documentation of Indigenous languages. As in 1999, the number of places removed from the Queensland Heritage Register and the number of applications for development of registered places are reported, as is the proportion of collections stored under appropriate environmental conditions.



Stone ruins on Lizard Island, far north Queensland, may be linked to 19th-century bêche-de-mer fishing and are popularly associated with the incidents surrounding the deaths of Mary Watson, her baby son and two Chinese employees in 1881, following a confrontation with mainland Aborigines. (Photo: EPA)

Pressures

Heritage places

Numerous pressures on cultural heritage places are a direct result of human activities. These pressures arise from:

- development-related activities;
- limited awareness of heritage places;
- negative attitudes towards and perceptions of heritage places;
- the impacts of tourism and recreation; and
- socioeconomic factors.

Various government programs are contributing to an assessment of Queensland's natural heritage places by assessing the impacts of pest species, climate change, fire and clearing, and activities such as forestry, farming and fishing. These programs are reviewed in other chapters of this report. There is, however, no consistent assessment of the condition of the state's protected areas, or other listed natural heritage places.

Development

The pastoral industry, the mining industry and urban and rural development today account for the highest proportion of damage to Indigenous heritage places caused by human impacts. Since 1999, 41% of new Indigenous places reported to the EPA have suffered such impacts (table 9.17).

Under the Cultural Record Act, anyone who wishes to undertake a cultural heritage assessment of a particular area requires a permit. Such assessments are generally part of either an environmental impact assessment (EIA) process or academic research. Permits are also required to access Designated Landscape Areas (DLAs) under the Act. In 2001–02, 162 permits were issued: 84% were parts of the EIA process, 14% were for research purposes, and 2% were to visit a DLA. Figure 9.12 shows the number of permits issued for each of these purposes since 1997–98.

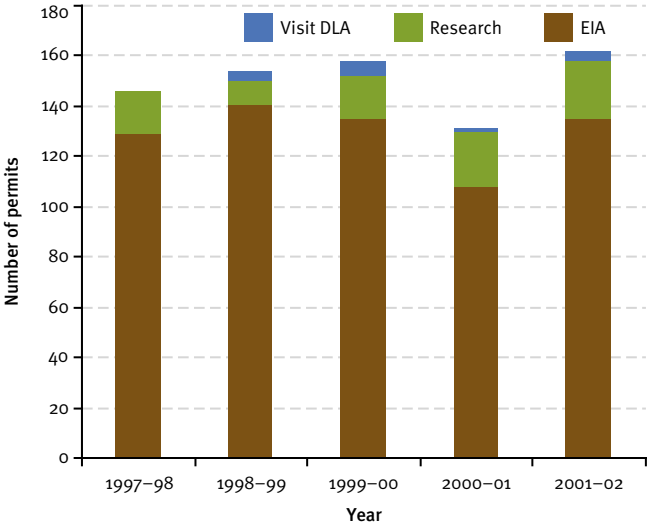


Figure 9.12 *Number of permits issued under the Cultural Record Act for environmental impact assessments (EIAs), research and visitation purposes, 1997–98 to 2001–02 Source: EPA*

Cultural heritage sites are more often identified as part of an EIA process related to development than by academic research. The number of permits issued under the Cultural Record Act therefore provides an indicator of a major pressure on cultural heritage sites, which may even include their destruction. Although there was a steady increase in the number of permits issued for EIAs from 1997–98 to 1998–99, there was a slight decrease in 1999–2000. A sharper decline in 2000–01 may be related to the decline in the building market around the time of the introduction of the federal Goods and Services Tax (GST). Supporting evidence for this is provided by the fact that more permits were issued in the first half of 2000 than after the introduction of the GST.

Development also places a major pressure on the condition of historical heritage places in Queensland. The National Trust (2002) has identified intensive development and inappropriate redevelopment as a major pressure on cultural and natural heritage places throughout Australia. Similarly, a survey of the condition of a sample of historical heritage places Australia-wide by Pearson et al. (2001) identified a number of pressures:



False Cape Gun Emplacement in 1943 and in 1995, Trinity Beach, Cairns. False Cape Second World War Defence Facility is important historically as the principal coastal defence for the port of Cairns, which served as a major transshipping port for Australian and United States armed services supplies and troop movements in the early 1940s. (Photos: EPA)

- loss of heritage values through changes for new uses —for example, the conversion of hotels into shops by stripping ground-floor interiors;
- loss of heritage values through modernising for ongoing use—for example, refurbishment of bank and post office interiors with modern facilities;
- regional town growth—towns experiencing high levels of commercial growth, such as Cairns and Port Douglas, face increased risks to heritage values. While former government buildings may retain streetscape values, they may have undergone damaging modifications; and
- large former government buildings at risk—in many cases, new uses cannot be found for buildings such as the post office and customs house in Rockhampton and the post office in Toowoomba, or new uses only partially occupy the available space.

The development of main streets, with facilities transferred to larger shopping centres, and the spread of suburban development are also pressures facing historical heritage places in Australia (Horrigan and Buckley 2002).

The development of historical heritage places entered in the Queensland Heritage Register is regulated by the provisions of the Heritage Act to minimise the impact on cultural heritage significance. In accordance with the Act, applicants proposing to develop heritage-registered places must seek the approval of the Queensland Heritage Council.

For all applicants other than the State Government, applications can be approved, either with or without conditions, or refused by the Queensland Heritage Council. In 2001–02, 66% of applications were approved without conditions, 18% received approval with conditions, and 5% were refused. Eleven percent of applications were ongoing or were withdrawn.

The role of the Queensland Heritage Council in relation to development proposals from the Crown for State Government projects is to recommend to the Minister responsible for the proposal whether the project should be carried out. Only 10% of development applications received in 2001–02 were from the Crown.

A total of 1580 applications for development of heritage-registered places have been received since the commencement of the Heritage Act in 1992. Figure 9.13 shows the number of applications received each year since the commencement of the Act.

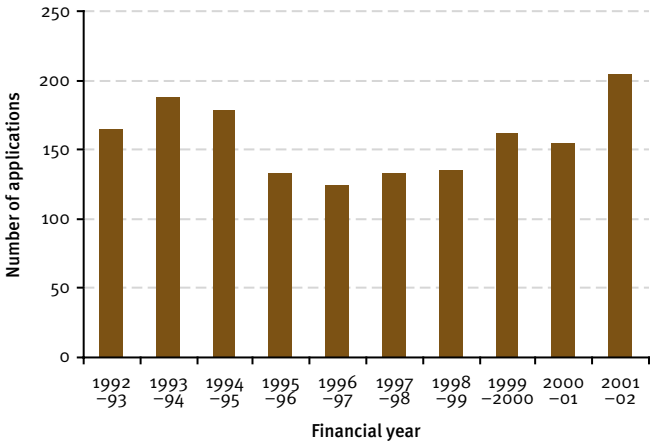


Figure 9.13 *Number of development applications received for proposals for development of places entered in the Queensland Heritage Register, 1992–2001*
Source: EPA

The decrease in the number of development applications received between 1993–94 and 1995–96 can be explained in part by a change in definition of the types of works excluded from development applications, such as maintenance or minor works. The decrease in 1999–2000 is possibly related to the downturn in the building industry at the time of the introduction of the GST.

The Queensland Heritage Council can remove a place from the Queensland Heritage Register if the cultural heritage significance of the place no longer justifies its retention in the Register. At 30 June 2002, a total of 76 places had been removed from the Register. Only 12 places have been removed from the Register since 1996–97 (table 9.14). The number of places removed from the Register each year is small in comparison with the number of places entered (table 9.14, figure 9.2).

Table 9.14 Number of places removed from and entered in the Queensland Heritage Register, 1996–97 to 2001–02

Year	Number of places removed	Number of places entered
1996–97	2	38
1997–98	0	29
1998–99	2	73
1999–2000	2	98
2000–01	3	88
2001–02	3	20
Total	**12**	**346**

Source: EPA

Awareness, attitudes and tourism and recreation

Damage to Indigenous heritage places is often a result of ignorance. Reports of damage by vehicular traffic reveal a lack of identification of Indigenous heritage places and a limited awareness of their existence. Since 1999, approximately one in every ten new Indigenous places reported to the EPA has been or is being affected by vehicular traffic (table 9.17).

Loss of heritage values at historical heritage places can also result from ignorance. Extensive and intrusive changes to enable new uses of historical heritage places, and uses inappropriate to the heritage values of a place, may be attributed in part to lack of knowledge of heritage values and the significance of a particular place. A narrow view of what constitutes heritage is also a pressure, particularly on historical heritage places. The current lack of recognition of 20th-century heritage puts places of current and future heritage value at risk (Horrigan and Buckley 2002).

Inadequate facilities and inadequate management of visitors to rock art sites can lead to accidental damage. A lack of understanding of the importance of Indigenous places can also result in inappropriate use or maintenance of a site, such as cleaning or 'touching-up' of art surfaces that is not in accordance with Indigenous cultural traditions. (See 'Visiting heritage places and collections', page 9.48.)

Damage is also caused by intentional acts of vandalism and/or theft, such as graffiti on Indigenous art panels, the theft or removal of historical and Indigenous artefacts as keepsakes or for illegal sale, and the deliberate destruction of cultural heritage places.

Permits are required under the Commonwealth *Historic Shipwrecks Act 1976* for exploration or recovery of historic shipwrecks and relics. In 2001–02, 55 permits were issued for the exploration of the wrecks of the *Yongala*, *Gothenburg*, *Aarhus*, *Llewellyn* and *Pandora*. Figure 9.14 shows the number of permits issued annually since 1996–97. (See table 9.33, page 9.49, for the number of divers visiting the *Gothenburg* and *Yongala* under permit.) The pressure of visitors to the *Pandora*, *Llewellyn*, *Gothenburg*, *Aarhus* and *Scottish Prince* is not of great concern, diver numbers being well under 400 a year. From 1996 to the present, however, annual visitor numbers to the *Yongala*, located in the Great Barrier Reef Marine Park off the coast of Townsville, have ranged from about 3800 to about 6700. Moorings installed at the wreck site in July 2002 will reduce the amount of damage caused by anchoring at the site, but it is predicted that this will see more than 10 000 divers visiting the site each year.

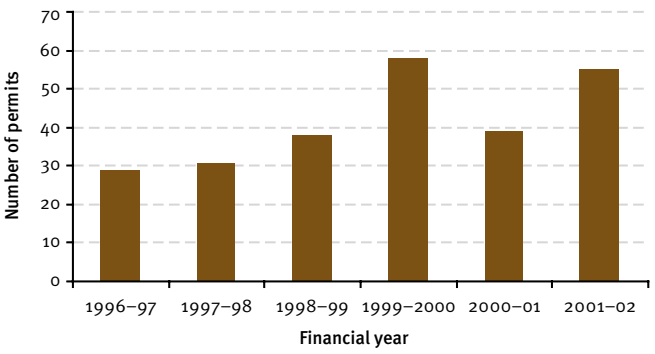


Figure 9.14 *Number of permits issued under the Historic Shipwrecks Act, 1996–2001*
Source: EPA



Environmental conditions, such as stable underwater environments, can sometimes protect the condition of historical items. However, extensive conservation work is required once items are removed from such protective surroundings. (Photo: Queensland Museum)

Socioeconomic factors

Changes in socioeconomic factors can also have a major impact on the condition of heritage places. Changes in technology, shifts in population and changes in rural use patterns have led to abandonment of rural places and townships throughout Australia (Horrigan and Buckley 2002). Subsequent neglect and abandonment of places have intensified the risk of deterioration (National Trust 2002). Redundancy of religious heritage places due to decreased demand for their use has also contributed to increased pressure (Horrigan and Buckley 2002). Asset rationalisation, mergers and technological and infrastructure changes in industry have made buildings redundant and put pressure on their conservation and maintenance (Horrigan and Buckley 2002). The increasing practice of assessing heritage places as assets with limited life spans has led to a lack of maintenance and placed another pressure on their preservation and conservation for the future (Horrigan and Buckley 2002). A further pressure is the under-resourcing of state and territory heritage bodies, which are then unable to assess, monitor and protect heritage places within their jurisdictions (National Trust 2002).

Heritage collections

Pressures on heritage collections held in museums and galleries include the existing condition of the objects in the collections, and the environment in which they are housed. Inappropriate environmental conditions can cause the deterioration of heritage collections. Table 9.15 shows the levels of climate control in the four major collecting institutions surveyed for this report. There has been minimal change in the levels of environmental control since 1999. The exception is the Cobb & Co. Museum, which reported a rise from 60% to 90% of its collection in full climate control. All except one of the major collecting institutions use thermohydrographs and data loggers to monitor and control temperature and relative humidity throughout the collection areas. Light and UV testing may also be undertaken. Although the collection of the Museum of Lands, Mapping and Surveying is located in the main air-conditioned building at the Land Centre at Woolloongabba, no systems are in place to monitor or control environmental conditions.

A qualitative review of small and regional museums and galleries in Queensland in 2000 for the national state of the environment report found that only a small percentage of small and regional museums have their collections stored in appropriate environmental conditions (Pearson et al. 2001). The level of climate control appears to correspond to the level of funding, well-funded museums having strong climate-control regimes that monitor light levels and humidity. The majority of small and regional museums have no environmental controls. The problems are more severe on the coastal strip, where humidity and mould are experienced, than west of the Great Dividing Range. By contrast, most of Queensland's regional galleries have highly controlled and appropriate environments, in which air-conditioning, monitoring of humidity and awareness of light issues conform to international standards (Pearson et al. 2001).

Queensland universities house a wide range of heritage collections, seven universities holding 42 collections (Pearson et al. 2001). Environmental conditions for heritage collections housed by Queensland universities are provided in table 9.16. Most collections have temperature control, few have humidity control, and most do not undertake monitoring.

The pressure of inappropriate environmental conditions for the storage of heritage collections in small and regional museums and for university collections in Queensland remains a challenge, although there appears to be limited pressure on collections in large institutions and regional galleries.

Table 9.15 Percentage of heritage collections under climate control in major collecting institutions in Queensland, at June 2002

	Queensland Museum					John Oxley Library	Queensland Art Gallery	Queensland State Archives
	South Bank	Museum of Tropical Queensland	Cobb & Co. Museum	Workshops Rail Museum	Museum of Lands, Mapping and Surveying			
Full climate control	95	95	90	98	0	100	95	100
Some climate control	0	0	0	0	0	0	5	0
No climate control	5	5	10	2	100	0	0	0

Source: EPA 2002i

Table 9.16 Environmental conditions of university heritage collections in Queensland

Environmental conditions	Percentage of collections
Heating and cooling	26
Cooling only	48
Neither	26
Humidification and dehumidification	5
Dehumidification	21
Neither	74
Monitoring undertaken in past year	9
Monitoring undertaken in past 5 years	9
No monitoring undertaken	82

Source: adapted from Pearson et al. 2001

Indigenous languages

The pressures on Indigenous languages are a result of a complex array of historical, political, economic and social forces. The colonisation of Queensland, the subsequent conflict between Aborigines and colonists, and later the assimilationist policies directed at Aboriginal and Torres Strait Islander peoples by Commonwealth and state governments saw a profound disruption of the cultural practices of Indigenous peoples (EPA 1999a). Apart from deaths resulting from frontier violence and introduced diseases, the forced removal of Indigenous peoples from their traditional lands to missions where traditional cultural practices were actively suppressed was the most significant cause of the loss of Indigenous languages. Many languages and the cultural meanings contained within them have been lost forever.

More recently, the loss of older language speakers and the fact that Indigenous languages are not being transmitted have placed even greater pressure on their state (Lennon et al. 2001). The reasons for this situation reside in the ongoing devaluation of Indigenous culture by non-Indigenous people, and the absence of a suitable economic base with which Indigenous cultural practices can be maintained.

The resistance to these pressures by Aboriginal people themselves and their search for solutions within the prevailing sociopolitical climate have been the main countering force (Langton 2002). The development of cultural tourism, the building of an international market for Aboriginal art, and Aboriginal and Torres Strait Islander participation in the management of natural resources resulting from native title processes have seen a cultural revival. There is renewed interest in Indigenous languages, and some languages considered extinct are being revitalised. Developments since 1999 may be alleviating some of the pressure on language. Initiatives such as the Cape York Partnerships Project aim to provide economic development for Indigenous communities, which may contribute to strengthening of culture (CYP 2000). While these efforts must be seen in context, there are signs that particular languages will be maintained and that others considered threatened will not be lost (see 'Condition and trends' below; 'Protecting Queensland's heritage', page 9.32; and 'Indigenous language and dispossession—museum exhibitions telling stories from the Stolen Generation', page 9.29).



Dancers performing at the Laura Dance Festival, Laura, far north Queensland (Photo: Tourism Queensland)

Condition and trends

Heritage places

All cultural heritage places are subject to damage through natural processes such as erosion and weathering. However, human impacts are far more likely to cause more intense and irreversible damage to both historical and Indigenous heritage places, as they may accelerate natural processes that are already under way.

Although there is no standardised monitoring of the physical condition of Indigenous heritage places in Queensland, site records included in the EPA's Indigenous Sites Database (see page 9.9) frequently include reference to impacts on site condition at the time of recording. Table 9.17 shows the number and type of human-related impacts on Indigenous sites reported to the EPA between 1999 and 2002.

While the figures provide a general indication of the impact on Indigenous heritage places, impact-related data are not always recorded for each site. Before 1999 such data were not consistently entered on the database.

The collection of data on the condition of historical heritage places is difficult, complex and expensive. Data on condition need to measure change; this requires an ongoing commitment, for which there are few resources and no detailed guidelines to ensure consistency. There are no current data on the condition of places entered in the Queensland Heritage Register (see 'Festival Hall, Brisbane', page 9.30).

A national survey was undertaken for the Commonwealth state of the environment report on the condition of a sample of historical heritage places listed in the Register of the National Estate (Pearson et al. 2001). The complex relationship between condition and integrity of historical heritage places was identified. The integrity of a historical heritage place relates to its heritage values and significance, and how well these are maintained. The condition of a historical heritage place relates to the physical fabric of the place and its change over time. Although the survey was problematic, in the representativeness of the sample and the level of assessment of interiors and complexes of buildings, it revealed the following general findings:

- commercial premises in urban centres and regional towns retain good condition externally, but have low integrity on the ground floor and interior. For example, few country town emporiums retain their internal fittings and layout, and those that do are significant because of their rarity;
- unoccupied buildings are an important issue, particularly in regional and remote areas (which were not well represented in the survey);
- there is no difference in condition between publicly and privately owned buildings, although publicly owned buildings generally have higher integrity;
- residential buildings are generally in fair to good condition and are relatively intact;
- churches retain a high integrity and fair condition overall, but the increasing need for maintenance is an issue; and
- many stone or brick masonry buildings are painted (contrary to past practices) to maintain a pleasing look and, in some cases, cover conservation problems.

The National Trust's Endangered Places Program (National Trust 2002) highlights heritage places under threat and encourages action to conserve them. The Australian Council of National Trusts releases a new list of endangered places annually and reports on the outcomes of the previous year's list. Of the 33 places identified nationally in 2001, two were in Queensland: the Annerley Army Reserve Depot, Brisbane, and Bullamon Homestead, Thallon. The former remains under threat, because although the heritage values have been acknowledged and heritage agreements are in place, the sale of the land on which it is located is proceeding and development has been approved. Bullamon Homestead also remains at risk due to a lack of funds for its conservation.



Bullamon Homestead, located near Thallon, west of Goondiwindi, is one of the rural homesteads identified by the National Trust as being endangered. (Photo: EPA)

Table 9.17 Number, proportion and type of human-related impacts on Indigenous sites reported to the EPA, 1999–2000 to 2001–02

	1999–2000		2000–01		2001–02	
	No. of sites	Percentage of total sites reported	No. of sites	Percentage of total sites reported	No. of sites	Percentage of total sites reported
Vandalism	5	0.41	1	0.13	1	0.11
Camping	2	0.16	3	0.39	3	0.32
Foot traffic	4	0.33	7	0.90	9	0.95
Vehicular traffic	77	6.33	80	10.30	79	8.30
Mining	5	0.41	24	3.09	17	1.79
Pastoral	179	14.72	205	26.38	70	7.35
Other development	201	16.53	330	42.47	177	18.59
Total		**38.89**		**83.66**		**37.41**

Source: EPA

The Endangered Places List (National Trust 2002) has identified not only individual places but also broader thematic types of places where condition is currently under threat. These include historical regional cinemas and rural homesteads. The Endangered Places list for 2002 identifies, at a national level, homesteads and other rural buildings that are threatened by neglect due to lack of use, the climate and vandalism. Places in Queensland on the Endangered Places list for 2002 include:

- Petrie Terrace Police Depot, Brisbane—neglect and inappropriate development threats;
- Point Lookout, North Stradbroke Island—development threats;
- Hinchinbrook Island and Passage, Cardwell—development threats; and
- traditional Caloundra beach houses, Caloundra—neglect and inappropriate development threats (see 'The National Trust's Endangered Places List', page 9.54).

There is no consistent or comprehensive approach to the assessment of condition of Queensland's protected areas. The Register of the National Estate has condition statements for listed places, but these vary in detail and are not updated regularly. At 30 June 2002, there were 320 places in Queensland listed for their natural heritage values. Those responsible for registered World Heritage sites are required to report regularly on their condition. In Queensland, the Great Barrier Reef Marine Park Authority produced a report, *State of the Great Barrier Reef World Heritage Area 1998* (GBRMPA 1999), and the Wet Tropics Management Authority produces an annual state of the Wet Tropics report (WTMA 2002).

The *Master Plan for Queensland's Parks System* (EPA 2001a) gives high priority to the natural integrity of our protected areas. It calls for the development of criteria for measuring integrity and the production of integrity statements for selected key parks in the short term and for all parks in the long term. QPWS is currently trialling Park Folio, a system that will be used to systematically record condition statements for protected areas in south-east Queensland.

The Great Barrier Reef Marine Park Authority (GBRMPA), in response to rising sea temperatures due to global warming, has instituted an extensive monitoring program to assess the extent of coral bleaching. It also has in place a long-term program to monitor crown-of-thorns starfish infestations.

Outcomes of research programs for particular places and species contribute to better knowledge of their condition. The research effort in the Wet Tropics region of north Queensland is an outstanding example of a successful program. This research includes mapping of canopy changes, studies of endangered species, and analysis of the impacts of tourism on the World Heritage area.

Heritage collections

The condition of heritage collections in museums and galleries can be assessed through conservation surveys of collections. The ability of the collecting institution to maintain or improve the condition of objects can be ascertained by examining the conservation activities undertaken.

Table 9.18 shows the level of conservation of collections, number of conservators employed and external conservation services used at 30 June 2002 in the four major institutions surveyed for this report. In five of the eight major collections, at least 50% of the collection has been surveyed. The Queensland Museum (South Bank) and the Queensland Art Gallery have, however, surveyed only small proportions of their collections. Only limited conservation treatment of collections has been carried out.

The findings of a qualitative review by Pearson et al. (2001) indicate that only small numbers of small museums in Queensland have been surveyed by conservators, and that, of these, only a few have undertaken subsequent conservation treatments. Conservators are usually called in to examine specific objects rather than total collections, and treatments are generally undertaken on a one-off basis, funded by grants. However, in most regional galleries in Queensland, full condition reports or condition notations have been recorded for assessed works, and most galleries have treated some of their works, usually prior to exhibition (Pearson et al. 2001).

Table 9.18 Levels of conservation and conservation treatment of heritage collections in major collecting institutions in Queensland, at 30 June 2002

Institution		Percentage of collection surveyed	Percentage of collection subsequently treated	Number of conservators employed	Use of external conservation services
Queensland Museum	**South Bank**	<1	<1	1 full-time 1 part-time	Yes
	Museum of Tropical Queensland	100	30	1 full-time 1 temporary	No
	Cobb & Co. Museum	50	10	0 (Uses staff of South Bank campus)	No
	Workshops Rail Museum	100	n/a	1 full-time	No
	Museum of Lands, Mapping and Surveying	50	0	0 (Uses staff of South Bank campus)	No
John Oxley Library		n/a	n/a	4 full-time	Yes
Queensland Art Gallery		5	n/a	3 full-time 7 part-time (6 of these temporary)	Yes
Queensland State Archives		100	n/a	6 full-time	No

n/a = not available

Source: EPA 2002i

Indigenous languages

As Indigenous people in Australia had no written tradition, language forms a key connection between people and country. It is one of the most significant aspects of the cultural heritage of any group. However, as language is intangible, it is often overlooked as people use it without reflecting on it or being conscious of it. Language is the most important means of expressing culture and communicating it to others, as well as transmitting it to the next generation (Lennon et al. 2001). In recent years, the Australian nation has begun to recognise the value of Indigenous cultures and languages, and to attempt to support Indigenous Australians in their efforts to maintain them (Lennon et al. 2001). (See 'Binangar Indigenous Centre at the Cobb & Co. Museum, Toowoomba', page 9.30.)

In 1999, four strong and nine severely threatened Indigenous languages were reported in Queensland (EPA 1999a). The 2001 Census provides new data on Indigenous languages in Queensland (table 9.19).

Table 9.19 Number of Indigenous language speakers, and the status of Indigenous languages in Queensland

Language	SoE 1999[a] (from Schmidt 1990)		ABS 2001[b]	
	No. of speakers	Status	No. of speakers*	Status
Kala Lagaw Ya	3000–4000	Strong	770	Strong, declining
Wik Mungkan	900–1000	Strong	600	Strong, steady
Thayore	500	Strong	n/a	n/a
Gugu Yalanji	300	Strong	200	Strong, declining
Guugu Yimithirr	400	Severely threatened	500	Strong, steady
Meriam Mir	100+	Severely threatened	180	Threatened, declining
Wik Nganthana	100–200	Severely threatened	n/a	n/a
Wik Nganjara	100	Severely threatened	n/a	n/a
Umpila	50	Severely threatened	n/a	n/a
Koko Bera	50	Severely threatened	n/a	n/a
Oykangand	50	Severely threatened	n/a	n/a
Yir Yoront	50	Severely threatened	n/a	n/a
Dyirabal	50	Severely threatened	n/a	n/a
Other Australian Indigenous language groups	nr	nr	160	n/a
Australian Indigenous language—no further definition	nr	nr	1240	n/a

[a]EPA 1999a; [b]ABS 2001 Census data
n/a = not available: this category of Indigenous language was not identified in the 2001 Census.
nr = not reported
*ABS figures rounded to the nearest 10. Where numbers of language speakers are low, ABS adjusts figures to prevent identification of individuals.

Table 9.20 and figure 9.15 show the numbers and distribution of Indigenous language speakers in Queensland by LGA, as derived from the 2001 Census. A total of 5891 persons in Queensland speak an Australian Indigenous language at home. Fifty-eight of the 125 LGAs in Queensland have no residents who speak an Indigenous language. The greatest numbers of Indigenous language speakers are in the far north of the state, in the Torres, Aurukun, Cairns, Cook, Carpentaria, Townsville, Douglas and Thuringowa LGAs. This result is consistent with that found Australia-wide by Lennon et al. (2001) and is not unexpected. These are the areas of the state that experienced contact with Europeans at a later time, where Indigenous communities that many non-Indigenous Australians perceive as being more 'traditional' are located, and where non-Indigenous populations are low. However, there are also pockets of greater numbers of Indigenous language speakers in the south-east of the state, and in central Queensland in the LGAs of Mackay, Duaringa and Livingstone. Lennon et al. (2001) noted that remoteness does not guarantee maintenance of an Indigenous language. For example, several languages in remote Cape York Peninsula are under severe threat.

Table 9.20 The 20 LGAs with the highest numbers of Indigenous language speakers, and the proportion of the Indigenous population speaking an Indigenous language, at August 2001

LGA	No. of Indigenous language speakers	Percentage of LGA's Indigenous population
Torres	1559	22
Aurukun	844	93
Cairns	715	6
Cook	691	24
Carpentaria	372	17
Townsville	281	6
Douglas	230	24
Brisbane	226	2
Thuringowa	167	6
Cardwell	73	10
Logan	53	1
Mount Isa	47	1
Herberton	46	7
Hinchinbrook	45	2
Mackay	38	1
Gold Coast	32	1
Rockhampton	29	1
Ipswich	29	1
Mareeba	24	1
Mornington	20	2
Total Queensland	**5891**	**5**

Source: ABS 2001 Census data

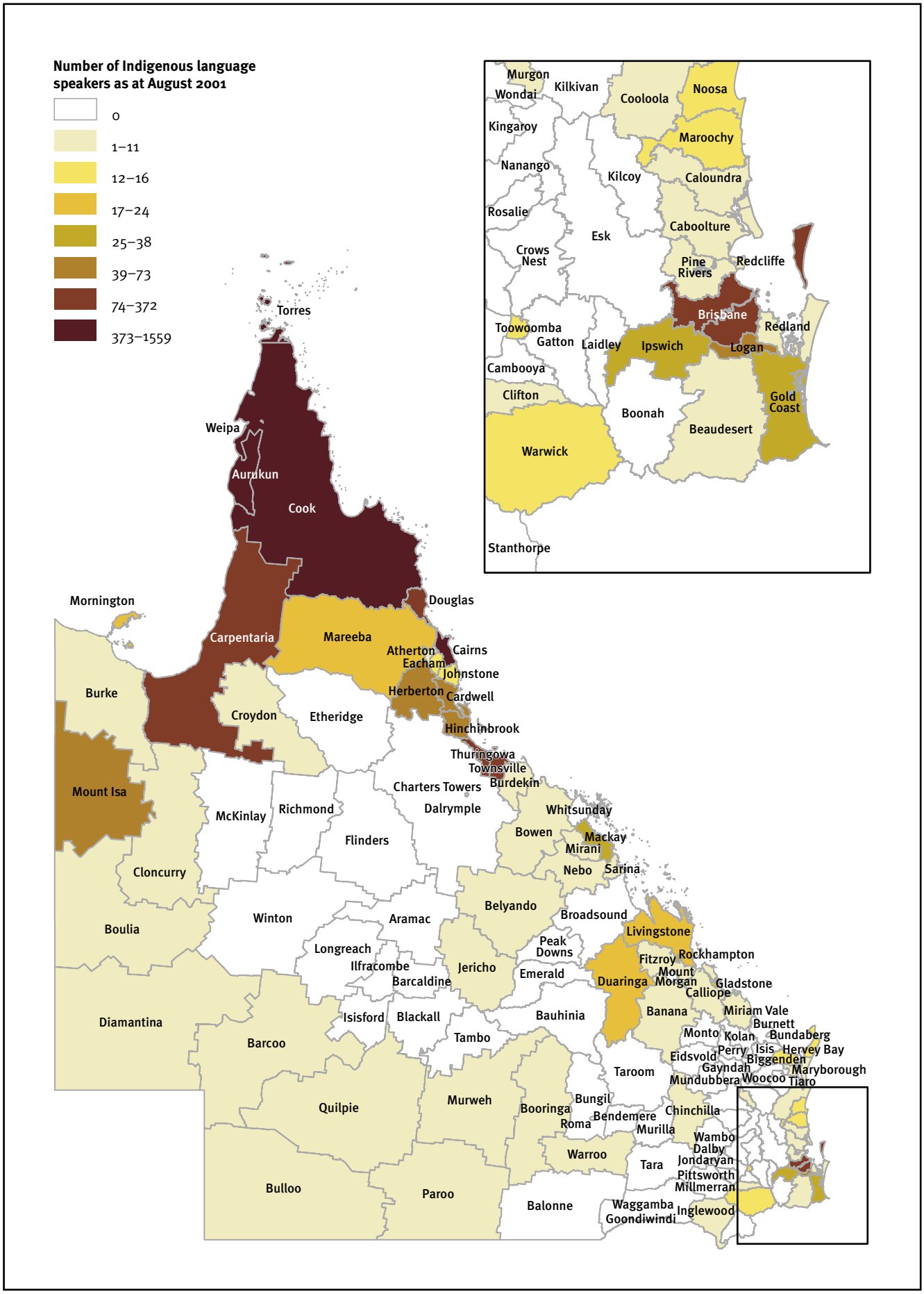


Figure 9.15 *Distribution of Indigenous language speakers by LGA, at August 2001*
Source: after ABS 2001 Census data

A comparison of the number of Indigenous language speakers as a proportion of the number of Indigenous people residing in each LGA reveals a slightly different picture. In Aurukun, 93% of the Indigenous population speak an Indigenous language. In Cairns, however, only 6% of the Indigenous population speak an Indigenous language, while in Brisbane only 2% do so.

While the EPA (1999a) reported that in 1990 there were 3000–4000 speakers of the Torres Strait Islander language Kala Lagaw Ya, the 2001 Census data (figure 9.16(a)) indicate that across Queensland there are approximately 800 speakers, 650 of whom live in the Torres Strait. The dramatic difference in the figures may be a reflection on methodologies rather than an actual difference, but requires more detailed investigation.

Meriam Mir speakers are much fewer in number, around 180 in the whole of Queensland. The Census data (figure 9.16(a)) show that the proportion of speakers is declining; while approximately 8% of Torres Strait Islanders over the age of 65 living in Torres Strait speak Meriam Mir, fewer than 1% under the age of 24 speak it. While the total number of Meriam Mir speakers reported in 2001 is greater than that reported in 1999, the language would still be considered severely threatened given the poor rate of transmission from older to younger speakers.

The proportion of speakers of both Kala Lagaw Ya and Torres Strait Creole is declining, from over 50% for people older than 65, to around 20% for those aged 5–14 years. While the total number of speakers of Kala Lagaw Ya is still relatively high, the reported decline in the proportion of speakers gives cause for concern.

Quite different trends are evident in three Aboriginal languages reported by the 2001 Census (figure 9.16(b)–(d)). Wik Mungkan and Guugu Yimidhirr (Guugu Yimithirr) have steady rates of speakers amongst all age groups, indicating that the languages are being successfully transmitted to the younger generation. There is a difference, however, in the proportion of speakers of the two languages. Twenty-two percent of the Aboriginal population of Cook Shire speak Guugu Yimidhirr, while in Aurukun Shire almost 60% speak Wik Mungkan. Taking into account people who reported speaking an Australian Indigenous language (without further definition), 95% of Aboriginal people living in Aurukun Shire speak an Indigenous language.

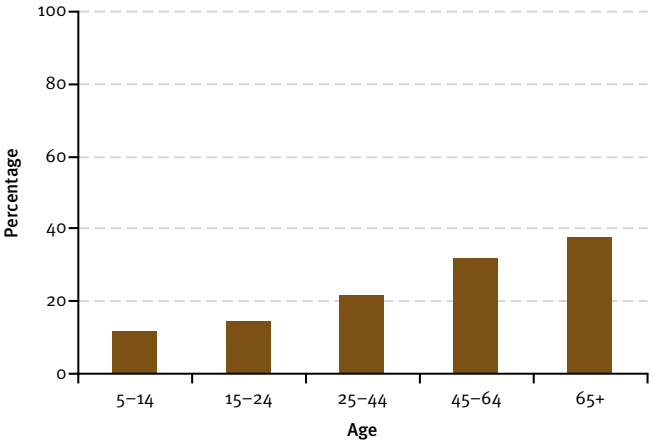


Figure 9.16(a) *Kala Lagaw Ya and Meriam Mir speakers as a proportion of the Torres Strait Islander population in Torres Shire*
Source: ABS

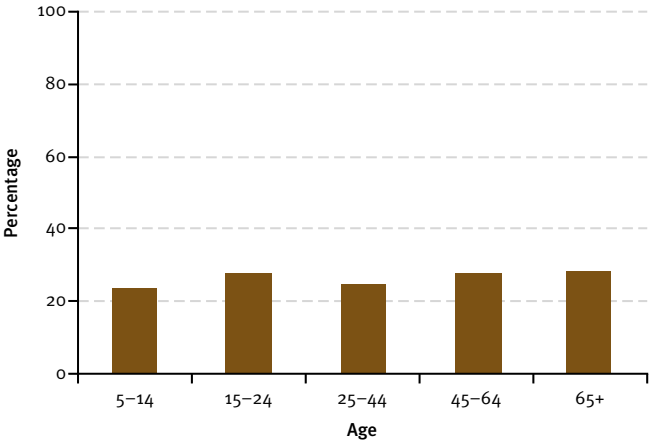


Figure 9.16(c) *Guugu Yimidhirr and other Australian Indigenous language speakers as a proportion of the Aboriginal population in Cook Shire*
Source: ABS

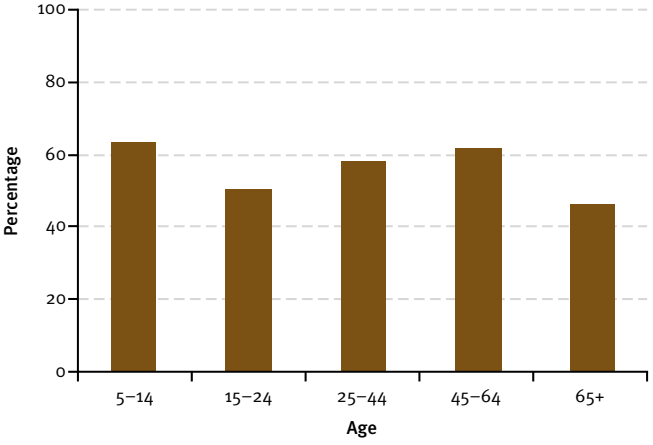


Figure 9.16(b) *Wik Mungkan speakers as a proportion of the Aboriginal population in Aurukun Shire*
Source: ABS

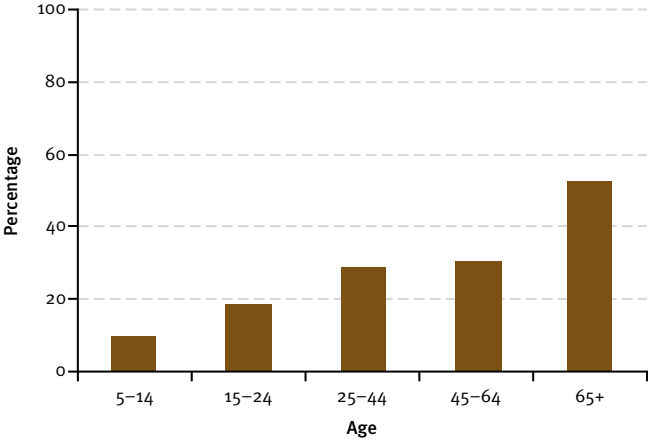


Figure 9.16(d) *Gugu Yalanji speakers as a proportion of the Aboriginal population in Douglas Shire*
Source: ABS

The situation is quite different for Gugu Yalanji (Kuku Yalanji). The vast majority of Gugu Yalanji speakers live in Douglas Shire, centred on Mossman. While between 24% and 30% of the Aboriginal population speak Gugu Yalanji, the rates are significantly lower amongst the younger generation. Only around 10% of Aboriginal people under 14 are speakers, contrasting with the rate of over 50% of Aboriginal people over the age of 65. This would suggest that without remedial action, there is a risk that Gugu Yalanji could become a threatened language.

Data for several of the threatened languages reported in 1999 and others described by the Federation of Aboriginal and Torres Strait Islander Languages (FATSIL 2002a, 2002b) were not picked up by the 2001 Census. However, the Census data show that there are around another 1400 speakers of Indigenous languages (either unspecified or belonging to another language group), and yet another 450 who speak an unspecified Torres Strait Island language. The figures derived from the ABS may differ from the actual numbers of speakers. The findings from a 1994 ABS survey of 17 500 Indigenous people indicated that there were 8% more people who identified themselves as speakers of an Indigenous language, but it was not the main language at home (McConvell and Thieberger 2001). This suggests that a more detailed survey is warranted, particularly in Torres Strait and Cape York, where a number of severely threatened languages are spoken. Another factor requiring further research is the number of people who are fluent in more than one Indigenous language.

Levels of documentation can be used as a measure of the condition or 'health' of an Indigenous language. Adequate levels of documentation are considered by McConvell and Thieberger (2001) to include the following aspects:

- dictionaries (from simple word lists to detailed dictionaries);
- texts (from example sentences to extensive text collections);
- grammar (from a few technical articles to a detailed grammar);
- ethnolinguistic information (from some information to a substantial work, such as a thesis); and
- audio recording.

Although comprehensive data about the levels of documentation for Indigenous languages in Queensland are not readily available, many examples of documentation along the lines described by McConvell and Thieberger (2001) are being undertaken as part of language programs and other projects throughout Queensland (table 9.21). It is uncertain, however, what effect this level of documentation is having on the maintenance and improvement of Indigenous languages in Queensland. A comprehensive survey of all Indigenous language documentation programs is required.

Table 9.21 Types of documentation for Indigenous languages in Queensland

Organisation	Language	Type of documentation
Australian Institute of Aboriginal and Torres Strait Islander Studies (AIATSIS)—Preserving Endangered Language Heritage Project	Butchulla Waka Waka Yugambeh Wangkumara Murawar	Audio recordings of vocabulary, grammar, narratives and songs
Birri-Gubba Wadja Bimbi Aboriginal Corporation	Birri-Gubba	Card games Dictionary Storybooks
Cape York Indigenous Language Program	Guugu Yimithirr	Stories Recipes Word lists Audio/video cassettes CD-ROM
Darumbal-Noolar Murree Aboriginal Corporation for Land and Culture	Dharumbal	Detailed grammar (see Terrill 2002)
Kombumerri Aboriginal Corporation for Culture	Yugambeh Wangerriburra	Teaching materials Lessons Children's books Audio and video tapes Book of John Lane's language recordings of 1912
Kowanyama Aboriginal Community Council	Uw Oykangand, Uw Olkola, Pakanh, Ayapathu	Multimedia dictionary including word lists and topical search index
Magani Malu Kes—Torres Strait Islander Language Consultative Committee	Torres Strait Islander languages including Meriam Mir and Kala Lagaw Ya	Booklets Recorded songs Library resources Language kit on CD, booklet and cassette
Nalingu Cultural Centre and community members	Gunggari	Board games Teaching resources
State Library of Queensland Indigenous Unit	Various	Detailed lists of recorded sound holdings
The Koori Centre, University of Sydney	Ngadjon	Glossary
University of Queensland Fryer Library	Various	Flint collection—Queensland Speech Survey 1960s Phonetic transcriptions of speech and song Recordings
Australian National University	Duungidjawu	Grammar (see Kite 2000)

Sources: FATSIL 2000, 2002a, 2002b; Kowanyama Aboriginal Community Council 1997; Bell et al. 1996; Elders of the Ngadjonji 2002; AIATSIS 2002; Queensland Heritage Council 2001

Responses

The management of development impacts is a major challenge that can be met successfully, as demonstrated by the Ports Corporation of Queensland (PCQ) at the port of Mourilyan. The PCQ project has managed to minimise impacts on both Indigenous and historical cultural heritage (see 'Managing corporate responsibilities—Ports Corporation of Queensland and Mourilyan', page 9.31).

The community and the local council at the old mining town of Ravenswood, through the establishment of a management committee, are also managing the pressure of mining development on historical cultural heritage resources (see 'Ravenswood—mining and management in north Queensland', page 9.31).

Provisions of the Heritage Act regulate development pressures on places entered in the Queensland Heritage Register. Impacts on the significance of these places are minimised through the application and approval process for non-Crown properties, and the provision of heritage management advice for Crown properties.

The National Trust established the Endangered Places Program to highlight heritage places under particular threat and encourage community and government action to conserve them (National Trust 2002; see also 'Condition and trends', page 9.23).

In response to damage being caused to the wreck of the *Yongala* on the Great Barrier Reef, moorings were installed in July 2002. They will reduce the damage caused by boats anchoring at the site. However, this response will also lead to increased pressure, as the number of divers visiting the site is predicted to rise to more than 10 000 a year. This example demonstrates the links between pressures on heritage resources and responses to these pressures.

GBRMPA has implemented a reporting system that enables members of the public to report possible breaches of marine park legislation, including wilful damage, vandalism or theft from cultural heritage places. To date, the system has had significant success. Although no exact figures are available on the number of incidents reported relating to cultural heritage sites, personal statements from management staff indicate that there have been minimal reports of damage. GBRMPA indicated that it expects that increased public awareness will lead to increased reporting of incidents in future.

A range of projects is being undertaken to document Indigenous languages in response to the threat of their loss. Audio recordings and written sources, incorporated into the communities, will assist in the retention of knowledge of Indigenous languages, and enable them to be passed on to future generations (table 9.21).

Summary of condition and trend indicators

Heritage condition

Indicator	Trend/ condition
Number of recorded Indigenous heritage places that have been adversely affected by human activity	?
Number of permits issued under cultural heritage legislation	▼
Number of places removed from the Queensland Heritage Register	▲
Number of applications for development of heritage registered places under ss 34 and 37 of the Queensland Heritage Act	▲
Number of historical heritage places assessed (by sampling) as being in (a) good, (b) average and (c) poor condition	X
Proportion of natural heritage places with protected area status	?
Proportion of collections surveyed by trained conservators/curators	–
Proportion of collections requiring conservation that are subsequently treated	?
Proportion of collections stored in appropriate environmental conditions	▲
Number and distribution of people who identify as speaking an Indigenous language	▼
Level of documentation for Indigenous languages in Queensland	▲

Key to condition:
Good
Moderate
Poor
Not assessed

Key to trend:
▼ Decreasing
▲ Increasing
? Not clear
X Not assessed
– No change

Case study: Indigenous language and dispossession—museum exhibitions telling stories from the Stolen Generation

A project funded through the ATSIC Language Access Initiatives Program and completed in July 2002 explored Indigenous language loss as a result of the effects of the Stolen Generation. It was undertaken through four museum exhibitions prepared and presented by Indigenous Language Officers (ILOs).

The first exhibition was set up in the local council library at Mitchell, in south-west Queensland, where the ILO told the story of Amy Doyle in *Nyia Gungarri—I am Gungarri*. Despite having lost some language, Amy always told her family who they were and where they came from, and late in her life made some recordings of her language; these were used in the exhibition.

Parallel Lives, an exhibition in Cunnamulla, was set up in partnership with the local council. It examined the lives of the Kunja people, explorers and pastoralists, and the Kunja people's resultant loss of language and cultural practices.

In the third project, the ILO formed a partnership between the Cobb & Co. Museum in Toowoomba and the local language program to establish the exhibition *Broken Links* at the Museum's recently opened Binangar Indigenous Centre, or 'listening place'. (See 'Binangar Indigenous Centre at the Cobb & Co. Museum, Toowoomba'.) The exhibition tells the story of two community members who were part of the Stolen Generation and explores the effects of government policy on the lives of ordinary people in a very moving display.

Finally, the ILO employed at the Burpengary library developed an exhibition entitled *Lost to the Act*. This exhibition told a more general story, relating the effect of mission life on Indigenous language and culture.

Sources: Yuke 2002; Tranter 2002

Case study: Festival Hall, Brisbane

Festival Hall, on the corner of Albert and Charlotte streets in Brisbane, was built in 1958–59. The site is important historically for its strong association with popular entertainment since 1910, especially boxing and popular music. Festival Hall also has historical significance as the largest public entertainment venue in Queensland until the opening of the Boondall Entertainment Centre in 1986, and for its association in 1959 with the celebration of the centenary of Queensland's separation from New South Wales. Festival Hall was considered to be a showcase for the Queensland construction industry, being at the forefront of design and technological expertise when it was built.

Despite its cultural heritage significance, the building has been sold and will be demolished, and a residential apartment tower constructed on the site. The place was nominated for entry in the Queensland Heritage Register, but the Queensland Heritage Council determined that it does not satisfy the criteria for entry in the Register because there is no prospect of its cultural heritage significance being conserved.

The determination was based on the following lines of evidence:

- Festival Hall is no longer commercially viable as an entertainment venue, and the number of patrons has dropped to 10% of those it had ten years ago;
- the large number of residential developments within the Brisbane CBD and resultant increase in the number of residents have led to concerns about excessive noise levels and the problems associated with large crowds attending the venue, making some live performances no longer possible or viable;
- the inner-city location presents significant problems in relation to crowd control and parking facilities; and
- the possibility of adaptive reuse of the building is limited, due to its design and construction and its location on a corner in the CBD.

Source: Horrigan and Buckley 2002



Festival Hall, Brisbane: View of Charlotte and Albert Street corner (left), balcony and auditorium seating (right) (Photos: EPA)

Case study: Binangar Indigenous Centre at the Cobb & Co. Museum, Toowoomba

The Binangar Indigenous Centre, opened in October 2001, is an integral part of the redevelopment of the Queensland Museum's Cobb & Co. campus as a Queensland Heritage Trails Network (QHTN) project.

A local Elder proposed the idea for an Indigenous centre when the QHTN project was first announced. A search was made for a base for an Indigenous Language Officer (ILO) in the Toowoomba region. A local Jarrowair Elder chose the name Binangar, or 'listening place'.

The Kombumerri Aboriginal Corporation for Culture established a partnership with the Museum and employed an ILO for 12 months to research the region's Indigenous languages and work with the Museum to develop a series of temporary exhibitions about local culture (see 'Indigenous language and dispossession—museum exhibitions telling stories from the Stolen Generation'). A booklet about Indigenous languages in the region has been published. The education staff from the Museum also work closely with the ILO to deliver education programs to primary and secondary students, and an Indigenous language component has been incorporated into some of these. A resource kit of local Indigenous stories tailored to the education curriculum is also being prepared.

The Museum's Gallery of Aboriginal Stories adjoins the Binangar Indigenous Centre, and features stories celebrating centuries of local Indigenous culture, families with historical connections who have settled in Toowoomba over the past 40 years, and the Bunya Nut Festival.

Binangar has far exceeded the purpose initially envisaged for it by members of the local Indigenous community, as a language research centre and a centre for changing displays of local culture. The Centre has also become one of the most popular features of the Cobb & Co. Museum and a popular meeting place for Indigenous and non-Indigenous visitors.

Source: Tranter 2002

Case study: Managing corporate responsibilities—Ports Corporation of Queensland and Mourilyan

The Ports Corporation of Queensland (PCQ) is responsible for the management and development of various ports throughout Queensland. The PCQ seeks to minimise the impacts of port operations or new developments on the natural, social and cultural environment through a policy of proactive management. This is based on environmental management policies developed in line with current environmental management systems standards (ISO 14001: 1996). All projects and developments require project-specific environmental management plans (EMPs) approved by the PCQ before any works commence.

The port of Mourilyan, approximately 100 km south of Cairns, is one of the eight trading ports and two community ports managed by the PCQ. A full cultural heritage assessment was undertaken as a component of the EMP for the port area, which was approved in September 2002.

The port was identified as having regional historical heritage significance due to its historical association with Queensland's sugar industry. The port and surrounding areas are the traditional lands of the Mamu peoples. Cultural heritage surveys of the port area revealed areas of cultural heritage significance to the Mamu people. Development buffer zones now protect these areas of cultural heritage significance.

Source: PCQ 2002

Case study: Ravenswood—mining and management in north Queensland

Ravenswood, listed in the Register of the National Estate and the Queensland Heritage Register, is significant as one of the great historical mining towns of Australia. It was the site of the first gold and silver discovery in northern Australia. It is also significant for its representation of 19th-century settlement patterns in north Queensland, its intact buildings and surviving mining landscapes.

Pressures

The harsh climate and natural events such as cyclones have had impacts on heritage structures and mining landscapes in Ravenswood.

Lack of funding for cultural heritage conservation is a factor in the decline of cultural heritage places in the town. The lack of technical and professional cultural heritage conservation expertise has made conservation of the heritage landscape difficult.

The introduction of modern, large-scale open-cut goldmining since the 1980s has put pressure on the surviving mining landscape. While modern mining has provided an economic revival for the town, it has also placed pressure on the 19th-century township.

Management

The Ravenswood Restoration and Preservation Association was established in 1987. Its members were drawn from the community and Dalrymple Shire Council. In 2000, the Association commissioned a conservation management plan for the township. A key recommendation was that a Cultural Heritage Management Committee of professional heritage practitioners, the community and Council be established. The committee is to be established in 2003.

By Helen Lucas, EPA



Ravenswood, north Queensland (clockwise from top left): School of Arts building, Thorps building, former newsagent and tobacconist, and Imperial Hotel (Photos: EPA)

Protecting Queensland's heritage

Summary

The Queensland, Commonwealth and local governments have continued to develop a management framework for heritage and allocated funds to protect heritage places. There has been a gradual development and consolidation in heritage management as described in 1999, through extension of protected areas, additions to heritage registers and the transfer of forest management to the Queensland Parks and Wildlife Service (QPWS). The nature and adequacy of protective measures have been controversial at times, for instance in the case of dingo management on Fraser Island.

The approach by government to natural heritage management has changed from protection of isolated areas (which historically have been listed for a variety of reasons, heritage value being just one) to the creation of a network of protected habitats on state and private land. Similarly, the significance of particular places is being viewed in terms of their relationship with broader ecological processes. The Parks Master Plan provides a framework for achieving comprehensive, adequate and representative protection of the state's biodiversity.

Other significant changes have resulted from the introduction of the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act), and the adaptation of the Queensland Government to these changes.

Overall funding for heritage appears to have levelled recently, having risen in some cases and fallen in others. There have also been some difficulties in Commonwealth–state funding arrangements. Increasing stringency in the overall economic situation and an atmosphere of economic constraint within government have meant that heritage is being measured increasingly through its capacity to deliver economic outcomes. There appears to be a growing resistance to taking measures that might impinge on economic performance.

The management of the five World Heritage sites in Queensland has seen increasing cooperation between state and Commonwealth governments through a number of joint initiatives. However, state–Commonwealth financial arrangements need to be improved.

Funding for heritage comes from a variety of sources, across different levels of government and different departments within government. Tracking fundings trends is difficult, and the difficulty has been compounded by changing accounting systems. While funding has increased in certain areas, particularly natural heritage management, it is not meeting growing demand.

Natural heritage receives considerably more funding than cultural heritage under separate arrangements which may not be appropriate in the light of the increasing overlap of natural and cultural heritage values being recognised by stakeholders. This recognition requires a convergent approach in resourcing and managing an increasing number of natural and cultural heritage places.

There are signs of some integration of the management of cultural and natural heritage places in Queensland. For example, the Wet Tropics Management Authority has made an effort to recognise both the cultural and natural significance of Queensland's Wet Tropics. The Parks Master Plan also gives recognition to cultural heritage aspects of the state's protected areas. There is still some way to go, however. The lack of a state cultural heritage policy impedes better-integrated management of heritage. Such a policy could be used to ensure that funding is applied to priority areas, and better aligned with funding for natural heritage.

Indigenous participation in the management of heritage at a local level has increased, particularly in north Queensland and in the Wet Tropics. This stands in contrast to the small progress in resolving native title claims and ownership of claimable protected areas a decade after native title was legally established.

Interest in Indigenous languages is increasing; particular languages are being revived, and threatened languages are being documented. However, the number of Indigenous language speakers is declining. There is no state policy on Indigenous languages, and support for them at a state level is low.

Queensland continues to maintain and develop its marine park system, having made some additions to reserves and released a draft planning framework. The State Coastal Management Plan (EPA 2002g), which came into effect in 2002, offers more systematic protection of coastal and marine heritage.

Heritage management requires greater coordination among the national, state and local governments. Differing approaches weaken the capacity of government to efficiently and effectively protect heritage.

Description

A framework of legislative and financial measures designed to protect Queensland's heritage is provided by all three levels of government (EPA 1999a). The character of these protective measures and their adequacy are reviewed below. Most of the indicators examined have not been reported on previously. They include:

- funding for and management of natural heritage and protected areas;
- funding allocated to Queensland Government agencies for the management of cultural heritage places and collections;
- funding and support provided by the State Government to communities and local government for cultural heritage;
- state and local government agencies' involvement in cultural heritage studies;
- the number of Indigenous people employed in government for cultural heritage management;
- the existence of Indigenous language programs in an educational setting;
- funding and support provided by government for small museums; and
- the number of museums with collection policies.

Pressures

A range of competing interests influences society's willingness and capacity to adequately manage its heritage. The prevailing pattern of economic development often conflicts with heritage protection and conservation. While there are increasing attempts to embrace sustainable practices within economic development, the dominant pattern of growth places a heavy reliance on government to regulate and manage heritage. The priority given to heritage management and the amount of funding available to government fluctuate according to economic and political conditions.

Condition and trends

Commonwealth, state and local laws, along with regulations and policies, help protect Queensland's heritage. Key features and changes to management arrangements since 1999 are discussed below.

International conventions

Australia is a signatory to a number of international and bilateral conventions (table 9.22). Since 1999 it has signed two new agreements, but has not ratified the Kyoto Protocol on climate change. This is significant in that climate change is one of the major concerns in relation to the future of two World Heritage Areas in Queensland, the Great Barrier Reef and the Wet Tropics.

Table 9.22 International conventions for environmental protection

Convention	Status	Year
International Convention for the Regulation of Whaling	Ratified	1946
World Heritage Convention	Ratified	1974
The Ramsar Convention on Wetlands	Ratified	1975
Convention on International Trade in Endangered Species of Wild Fauna and Flora	Ratified	1976
Convention on the Conservation of Antarctic Marine Living Resources	Ratified	1982
Convention on the Conservation of Migratory Species of Wild Animals (the Bonn Convention)	Ratified	1991
Convention on Biological Diversity	Ratified	1993
Cartagena Protocol on Biosafety	—	—
United Nations Framework Convention on Climate Change	Ratified	1992
The Kyoto Protocol	Signatory	1998
Working Group on Criteria and Indicators for the Conservation and Sustainable Management of Temperate and Boreal Forests (The Montreal Process)	Member	1994
Convention to Combat Desertification	Ratified	2000
The Agreement on the Conservation of Albatrosses and Petrels	Ratified	2001

World Heritage

World Heritage sites are listed under the World Heritage Convention, which is administered by the United Nations Scientific and Cultural Organization (UNESCO). As a signatory to the convention, the Commonwealth Government has the primary responsibility for World Heritage sites in Australia. It has entered into agreements with state governments to jointly manage World Heritage sites. Within Queensland, funding and management of World Heritage sites and other protected areas are intertwined, so the amount of funding at the state level is not always clear.

Funding for World Heritage is derived partly from the Natural Heritage Trust (NHT), as well as direct appropriations for the Great Barrier Reef Marine Park Authority (GBRMPA 2000, 2001, 2002b). The reorganising of the Natural Heritage Trust, which subsumes World Heritage under other programs for which agencies expend considerable time and effort to competitively apply for funding, raises questions about the efficacy of project funding for World Heritage.

Figure 9.17 compares funding and expenditure for Queensland's World Heritage. The expenditure estimates may not account for all spending by the EPA or QPWS, as some corporate functions also support World Heritage management. Even so, the figures show that specific allocations fall far short of actual expenditure.

Figure 9.18 shows that the majority of government funding goes to managing the largest of the World Heritage areas, the Great Barrier Reef Marine Park, which is jointly managed by the Commonwealth and Queensland governments. GBRMPA has overall responsibility for the park, while QPWS is responsible for day-to-day management, which is co-funded approximately equally by the state and Commonwealth. Other funding for the Great Barrier Reef is derived from a variety of sources at both Commonwealth and state levels, including the Australian Quarantine and Inspection Service, the Reef CRC and fisheries patrols. It has been estimated that total expenditure on reef protection exceeded $60 million annually (Lennon et al. 2001).

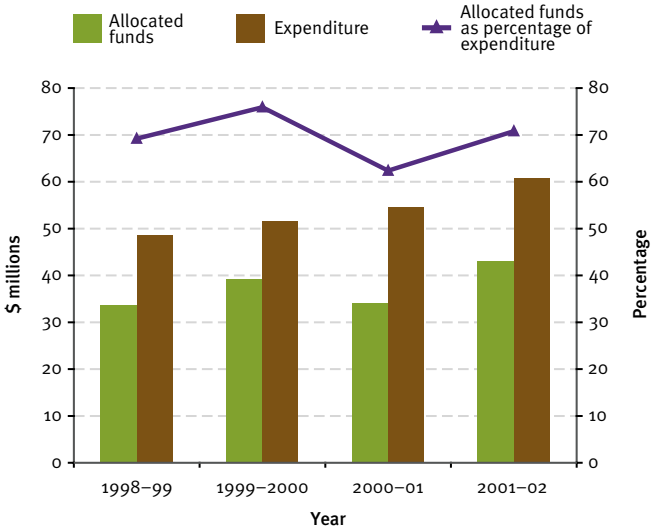


Figure 9.17 *Funding for Queensland's World Heritage areas—allocated funds and total expenditure*
Sources: GBRMPA 2000, 2001, 2002b; EPA

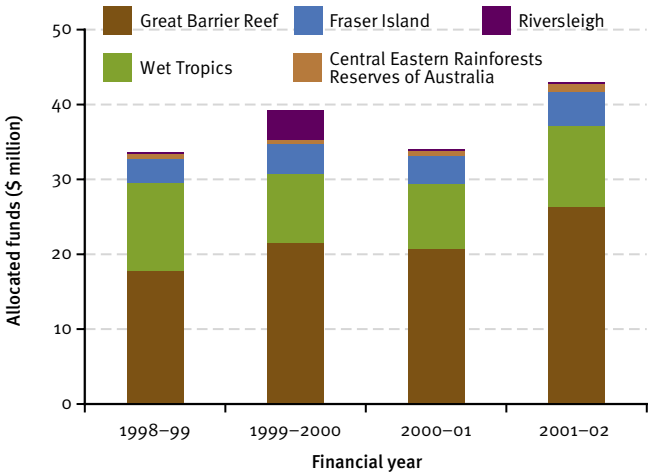


Figure 9.18 *Allocation of funds for Queensland's World Heritage areas*
Sources: GBRMPA 2000, 2001, 2002b; EPA

Developments in the management of Queensland's World Heritage sites since 1999 include:

- the release of *The Riversleigh Management Strategy* (EA and EPA 2002), which provides a framework for maintaining the integrity of the Queensland section of the Fossil Sites World Heritage Area. The strategy defines the Commonwealth–State relations under which QPWS manages the site on behalf of the Commonwealth, and requires funding agreements between the two levels of government. A consultative committee has been established with the traditional owners, the Waanyi people, and an interpretive centre is now operating. The strategy also provides a framework for negotiation with the owners of a privately owned section of the World Heritage Area;
- the creation of two new intergovernmental committees, the Community Advisory Committee and the Technical and Scientific Advisory Committee for the Central Eastern Rainforest Reserves of Australia, which have cultural heritage representation;
- a program of culling of the dingo population and fencing of some camping areas on Fraser Island following the death of a boy which resulted from an attack by a dingo;
- increasing tension between the Queensland Government and the Commonwealth Government over funding for the Wet Tropics Management Authority, exacerbated by the lack of a funding agreement between the two levels of government;
- extension of the Great Barrier Reef Marine Park, and the commencement of the Representative Areas Program, including the release of management plans for the Cairns area and the Whitsundays and a draft management plan for Hinchinbrook; and
- initiation of a joint Commonwealth–state Water Quality Protection Plan for the Great Barrier Reef.

Ramsar wetlands

In late 2002, additions to sites listed under the Ramsar Convention on Wetlands included the Coral Sea Reserves (Coringa-Herald and Lihou Reefs and Cays), located north-east of the Great Barrier Reef. This brings the number of Ramsar sites in or offshore from Queensland to six, with a total area of 2 361 914 ha (table 9.23).

Table 9.23 Ramsar sites in Queensland

Ramsar sites	Area (ha)	Date listed
Bowling Green Bay	35 500	22.10.1993
Moreton Bay	113 314	22.10.1993
Currawinya Lakes	151 300	11.03.1996
Shoalwater/Corio Bays	239 100	11.03.1996
Great Sandy Strait	93 000	14.06.1999
Coral Sea Reserves	1 729 700	18.11.2002
Total	**2 361 914**	

Source: EA 2003

National framework

The Australian Heritage Commission administers the Register of the National Estate (RNE). Details of the Queensland component are given on page 9.4.

The *Australian Natural Heritage Charter for the Conservation of Places of Natural Heritage Significance* was revised in 2002 (AHC 2002b). The charter provides a set of principles to aid the identification and management of natural heritage places, through conservation processes and practices. It recognises the overlap between natural and cultural heritage places.

The Commonwealth EPBC Act introduced a national framework for the protection of natural heritage of national significance. It provides an overarching referral and approval system for development that may threaten areas of national significance. The Commonwealth and Queensland governments have drafted a bilateral agreement on the application of the EPBC Act to ensure cooperation and minimise duplication. Amendments to the EPBC Act presented to the Commonwealth Parliament in 2002 will create a new regime for the protection of national heritage sites through the development of new lists of National Heritage and Commonwealth Heritage, which will include cultural sites. The Commonwealth and Queensland also have an agreement to develop an integrated management system for Australia's heritage regime, with priorities based on the 2001 Australian state of the environment report.

From the enactment of the EPBC Act until 30 June 2002, 126 referrals relating to Queensland were made to the Commonwealth; of these, 52 were defined as controlled actions, requiring specific approvals (EA 2002a). Third party rights were established when, in 2001, an injunction by the Federal Court of Australia was issued restraining the electrocution of a population of the spectacled flying-fox (*Pteropus conspicillatus*) adjoining the Wet Tropics World Heritage Area. By November 2002 a joint Commonwealth–state agreement on the management of threatened flying-foxes was in place.

The Commonwealth Government, through the National Strategy for the Conservation of Australia's Biological Diversity (DEST 1996), and the *National Objectives and Targets for Biodiversity Conservation 2001–2005* (EA 2001b), supports additional measures for natural heritage, inasmuch as biodiversity is an essential element of natural heritage. These national objectives and targets aim to bridge the gap between current activities and the effective identification, conservation and management of Australia's biological diversity.

The Commonwealth also has programs in conjunction with the Queensland Government for heritage protection. One of the major initiatives has been the commencement of the Reef Water Protection Plan (see 'World Heritage', page 9.33).

Federal funding

Federal government agencies and departments such as Environment Australia, the Aboriginal and Torres Strait Islander Commission (ATSIC) and the National Library of Australia fund heritage grants programs.

Since 1997, the Commonwealth Government's major funding initiative for heritage has been the NHT, used for environmental projects on public and private land, and coasts and waterways. While the NHT was originally funded from the partial privatisation of Telstra, in 2001 the Commonwealth committed funds from consolidated revenue for an extension of the program to 2006–07.

Programs funded by the NHT (table 9.24) have recently been consolidated from 23 to four: Bushcare, Landcare, Rivercare and Coastcare. Under Envirofund, a specific fund for community-based environmental projects established in 2002, $3 million was allocated to projects in Queensland in 2002–03.

Table 9.24 Natural Heritage Trust funding ($ million)

Program	1998–99	1999–2000	2000–01
Natural Heritage Trust Funds allocated to Queensland projects	45.3	42.6	45.9

Sources: EA 2000, 2001a, 2002c

Other Environment Australia funding programs include the Cultural Heritage Projects Program and the Commemoration of Historic Events, Famous Peoples Program. Also offered are grants to state heritage trusts, and the National Cultural Heritage Account, which provides funding for the purchase of protected objects as defined by the *Protection of Movable Cultural Heritage Act 1986* (Cwlth).

ATSIC social and cultural programs provide financial support for Indigenous heritage protection projects, language maintenance, housing, native title, Indigenous arts and cultural programs, and reconnection programs such as the 'Link Up' initiative. ATSIC programs included 15 natural heritage projects in Queensland in 2001–02. Since the creation of the Indigenous Land Fund for the purchase of land, 30 properties in Queensland, many of which have heritage values, have been purchased (ILC 2002). Under this program, mechanisms exist for the declaration of purchased land as Indigenous Protected Areas. The Warul Kawa Island Indigenous Protected Area, located in the Torres Strait and covering approximately 3500 ha, was declared in April 2000, while the Guanaba Indigenous Protected Area (approximately 100 ha) adjoining Mt Tamborine National Park in the South East Queensland bioregion was declared in November 2000. (See pages 9.39 and 9.47 for more information on the involvement of Indigenous people in heritage management.)

The National Library of Australia operates a community grants scheme to assist in the preservation of significant documentary heritage collections.

State measures

Broad measures for protecting the natural environment are described in Chapter 4, 'Land', and Chapter 7, 'Biodiversity'. The heritage aspects of these measures, as opposed to more general environmental protection, are not clearly delineated in the current management regime. Protection for natural and cultural heritage in Queensland is provided by separate legislation; the *Nature Conservation Act 1992* deals with the protection of natural heritage areas, while cultural heritage is managed through the *Queensland Heritage Act 1992* and the *Cultural Record (Landscapes Queensland and Queensland Estate) Act 1987*. However, the *Integrated Planning Act 1997*, the State Coastal Management Plan (EPA 2002g) and the *Master Plan for Queensland's Parks System* (EPA 2001a) draw links between cultural and natural heritage management.

Natural heritage

At 30 June 2002, 7 124 585 ha of land (4.1% of the state) had been gazetted under the Nature Conservation Act as various types of protected areas (see Chapter 7, 'Biodiversity').

In 2001, QPWS released the *Master Plan for Queensland's Parks System* (EPA 2001a), providing an overarching framework for the management of Queensland's protected areas over the next 20 years. Individual parks also have their own management plans, which include provisions for both cultural and natural heritage. At 30 June 2002, 93 of the 219 parks and protected areas in Queensland (42%) had a management plan in place, compared with 57 in June 1999. In 2002, administrative arrangements for the protection of natural heritage changed, responsibility for forests being transferred from the Department of Natural Resources and Mines to the EPA. This was accompanied by the creation of new land tenure categories of 'Forest Reserve' and 'National Park (recovery)' to deal with the transfer of state forests to national parks.

Other areas dedicated to the protection of particular species include the Koala Conservation Area and Dugong Protection Areas, declared in 1997.

Areas protected under state legislation may not necessarily be listed in the Register of the National Estate (RNE), and, conversely, places in the RNE may not be protected by the state. How many of the 320 natural heritage places in Queensland in the RNE fall within state protected areas is unknown.

Funding for the management of Queensland's protected areas and other land administered by QPWS is reported annually to the Australian and New Zealand Environment and Conservation Council. Both total recurrent operating costs and labour costs have risen gradually over the reporting period (table 9.25). Figure 9.19 shows that there has been an increase in the amount of spending on a per area basis since 1994–95. While the graph shows that spending on a per visitor basis has risen marginally, the visitor figures used for this calculation are estimates only, so any trend should be interpreted in this context.

The percentage of costs met by income derived from visitors has levelled at approximately 17% over the past four years, rising from 13% in 1994–95.

Table 9.25 Financial measures for Queensland Parks and Wildlife Service

Year	Total recurrent operating cost ($ million)	Total annual labour cost ($ million)	Total revenue ($ million)
1998–99	35.8	22.5	6.3
1999–2000	41.4	24.2	7.1
2000–01	43.6	27.8	7.3

Source: QPWS

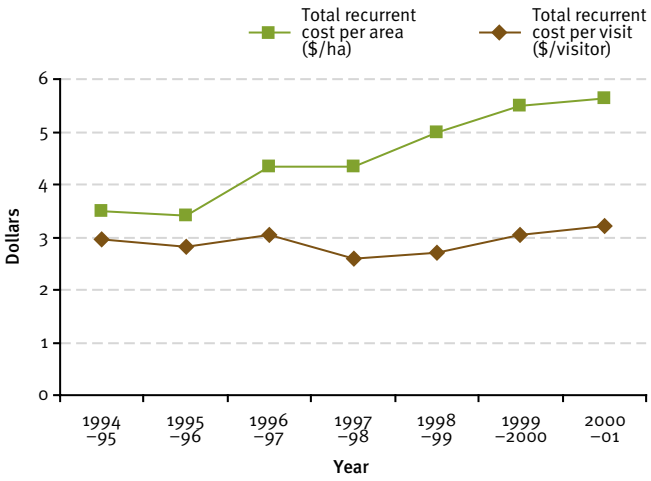


Figure 9.19 *Spending on land managed by QPWS on a per area and per visitor basis*
Source: QPWS

Private individuals and groups are also funding heritage protection. The purchase of north Queensland properties with endangered species habitat with the express purpose of creating a nature refuge is an example of such action. The increasing number of privately owned nature refuges and land for wildlife agreements shows a growing commitment by private landholders to contribute to heritage protection. In June 2002, the 73 nature refuges in Queensland covered 33 209 ha. Quantitative assessment of the amount and effectiveness of private contributions is not available.

Since 1999, the EPA has published a draft planning framework for marine protected areas in Queensland (EPA 2000b). Other initiatives in the management of coastal areas include the State Coastal Management Plan (EPA 2002g), which came into effect in 2002 (see Chapter 6, 'The coastal zone'). This plan provides for an integrated approach to managing development along Queensland's coastline and deals with heritage issues. The Queensland coast has been divided into 11 zones, each of which will eventually have its own plan. Draft plans for the Curtis Coast and the Cardwell-Hinchinbrook Region were released in 2002 for public comment. Protection of Queensland's coastal habitats is offered by the system of marine parks zoned for multiple purposes. Apart from the Great Barrier Reef Marine Park, there are seven marine parks. Since 1999, borders for fish habitat areas declared under the *Fisheries Act 1994* have been reviewed (see Chapter 6, 'The coastal zone').

Cultural heritage

Few changes have been made to the framework for the management of cultural heritage in Queensland since 1999; the Heritage Act and the Cultural Record Act remain the principal legislative mechanisms for the protection of cultural heritage places. In 1999, Queensland had no state cultural heritage policy, and this remains the case. The lack of such a policy is an impediment to the integration of cultural heritage management with other regulatory processes.

The identification and management of cultural heritage places are becoming increasingly important for local governments in Queensland since the introduction of the Integrated Planning Act. As lead agency for cultural heritage management in Queensland, the EPA developed a set of cultural heritage management guidelines for local governments on how to meet their statutory obligations. The guidelines describe approaches for the identification of Indigenous and historical cultural heritage places, provide information concerning relevant pieces of Commonwealth and state heritage legislation, and give additional sources of information (EPA 2001b).

In August 2002, the QPWS Forestry and Wildlife Division introduced the QPWS Cultural Heritage Manual (the QPWS Manual) to assist with the implementation of improved protective management outcomes for cultural heritage values located on the EPA estate. The QPWS Manual was developed by a multi-agency group, which included staff from the EPA, the Departments of Natural Resources and Mines, Main Roads and Aboriginal and Torres Strait Islander Policy Development, and heritage professionals, academics and Indigenous representatives.

The QPWS Manual provides general information on the management of cultural heritage values and operational guidelines, protective management prescriptions and management profiles for different types of places designed to suit the needs of operational staff working in Queensland's state forests and national parks. It is intended to integrate the protective management of cultural heritage values with the methodologies and practices associated with the management of natural heritage values. The manual's provisions apply to all operations conducted under the *Forestry Act 1959* (principally timber harvesting operations) on state lands. By March 2003 more than 140 QPWS and DPI Forestry staff across the state had been trained in its use.

Cultural heritage studies by state and local government agencies

A survey of state government agencies was undertaken in October 2002 to determine the nature of any current cultural heritage activities. The results are given in table 9.26.

Table 9.26 Summary of cultural heritage survey of Queensland government agencies

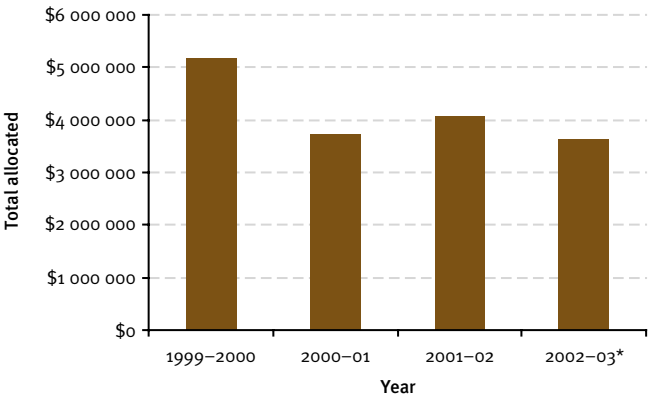
Activities undertaken for cultural heritage management	Number
Departments and other agencies surveyed	24
Responded to survey	21
General management of cultural heritage	17
Assessment of cultural heritage assets and asset management policies	7
Conservation studies and refurbishment of heritage-listed properties	6
Collections management and support of local museums	4
Management of cultural heritage issues in relation to environmental impact assessments	3
Raising public awareness through publications and/or other activities	3
Cultural tourism projects including sponsorship	2

In the absence of any specific legislative requirement, the survey indicated that a number of agencies are starting to recognise the importance of cultural heritage management within their portfolios (see 'Queensland Rail—recent cultural heritage achievements', page 9.43), although the levels of involvement could be increased. This indicator will be monitored in future reporting cycles.

Local government authorities (LGAs) were also surveyed about whether they had undertaken cultural heritage surveys within their boundaries. Forty-five percent of the 88 respondent LGAs have conducted surveys for historical cultural heritage, while only 20% have undertaken surveys for Indigenous cultural heritage (see page 9.11). Of the LGAs that have undertaken a cultural heritage survey, the majority report having surveyed 75–100% of their area (table 9.12). However, because there is no consistent measure of the thoroughness of these surveys, some cultural heritage places may still be undeclared or unrecognised. The results of the survey highlight the need for LGAs to take further action to meet their responsibilities in the management of Queensland's cultural heritage.

Funding

Funding provided for the EPA's Cultural Heritage Program in 2001–02 totalled $4 062 101 (figure 9.20). The EPA and its predecessors have operated heritage grants programs from the allocated funds since 1989.



*The funding for the 2002–03 financial year is a budgetary estimate only and includes carry-over funding from the 2001–02 financial year.

Figure 9.20 *Total funding for the EPA Cultural Heritage Program by financial year, 1999–2003*
Source: EPA

These programs have funded Indigenous and historical heritage projects. Funding is also available for community-based and local government heritage projects. Requests for funding significantly exceed available funds (figure 9.21). After 1999, the grant program was run on a two-yearly basis.

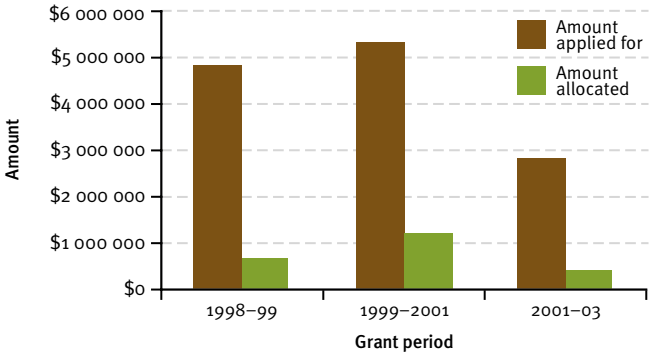


Figure 9.21 *EPA Cultural Heritage Grants Program, 1998–2003*
Source: EPA

Details of cultural heritage funding from the EPA show that, in the 1998–99 program, a total of $183 925 was provided to local governments to support heritage projects and a further $488 362 was allocated to other projects. In 1999, separate Indigenous, historical and community history grants programs were amalgamated into a single cultural heritage grants program. The 1999–2001 grants program provided $710 942 for local government projects and $492 930 for other projects. The 2001–03 Queensland Community Cultural Heritage Incentive Program (QCCHIP) has provided a total of $219 750 to community organisations, and a further $190 730 to local government.

Other Queensland government agencies operate grants programs that support cultural heritage projects. These include programs by the Department of Aboriginal and Torres Strait Islander Policy (DATSIP), such as the Community and Personal Histories Program, which assists Indigenous organisations and individuals to document family and community histories. However, this program was discontinued after the 2000–01 grants round (figure 9.22). The Queensland Heritage Trails Network, a joint Queensland and Commonwealth Government initiative, also provided more than $3 million over two years (2000–02) through its Cultural Tourism Incentives Grants, a program for cultural heritage projects that support the operation of the Network (see also page 9.52).

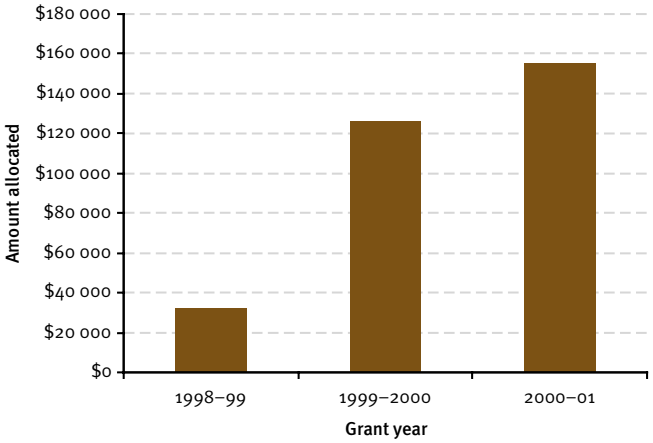


Figure 9.22 *DATSIP Community and Personal Histories Program grants funding, 1998–2001*
Sources: DATSIP 1999, 2000, 2001

Cultural heritage collections

Table 9.27 shows funding for Queensland government collecting institutions in the period 1998–2002. Significant funding was allocated for the development of the Workshops Rail Museum at Ipswich between 1999 and 2000.

Table 9.27 Funding for state government agencies responsible for the protection and/or promotion of cultural heritage places and collections, 1998–99 to 2001–02 ($ million)

Year	EPA Cultural Heritage Program	Qld Museum	Qld Art Gallery	Qld State Archives	State Library
1998–99	n/a[a]	11.84	9.06	4.95	34.45
1999–2000	5.15	11.89[b]	9.33	4.89	35.12
2000–01	3.73	12.01[b]	9.45	4.92	35.28
2001–02	4.06	12.51[b]	10.16	5.40	36.78

[a] Funding information for the years before 1999 is not comparable with that for subsequent years due to changes in accounting procedures.
[b] Between 1999 and 2002, a total of $15 million was also allocated to the Workshops Rail Museum at Ipswich. This museum is a joint project funded by the Queensland Museum and Queensland Rail.

Source: EPA 2002i

Arts Queensland offers a range of grants programs that support cultural projects as well as a program of assistance for museum-related activities, introduced in 2001. Museums can apply for either small grants of under $5000, or larger grants through Arts Queensland's major grants program. Funding is provided for operational expenses and for a range of project types (table 9.28).

Collection policies provide a means for museums to manage the cultural heritage material they hold, providing a focus for the acquisition of new material and ensuring that the material collected represents a coherent whole, rather than a series of unrelated objects (see 'Greenmount Homestead', page 9.44). It is not possible to determine how many museums in Queensland currently have collection policies, as statewide figures are not available. However, the four major collecting institutions surveyed for this report currently have collection policies that are approved, under review, or under development.

Table 9.28 Funding ($'000) provided to museums through Arts Queensland programs of assistance, 1998–99 to 2001–02

Arts Queensland programs of assistance	1998–99	1999–00	2000–01*	2001–02	Total
Museum Collections Management Fund	26.4	21.0	18.0	No data	**65.5**
Museums Development Officer Program	400.0	400.0	415.0	No data	**1215.0**
Museums Australia (Queensland)	180.5	175.5	175.5	590.5	**1280.5**
Regional Galleries Association Qld	190.0	176.0	275.0	190.0	**831.0**
Cobb & Co. Store Museum (Warroo Shire Council)	6.5	No data	30.0	30.0	**66.5**
Other museum funding[a]	100.3	95.5	2 244.1[b]	319.8	**2759.7**
Total funding	**903.7**	**868.0**	**3 157.6**	**539.8**	**5469.1**

[a] This includes funding provided to museums through various Arts Queensland programs, including the Cultural Facilities Program, the Major and Small Grants Program, and initiatives and sponsorships.
[b] Additional funding was granted to Arts Queensland under the Millennium Arts Regional Program, with substantial grants being made for either the establishment of new museums or the refurbishment of existing museums.

Source: Arts Queensland

Most of the institutions identified temporal, spatial and thematic gaps in their collections, which their collection policies sought to overcome. Current gaps and weaknesses were attributed to issues such as inadequate resources and staff, a lack of a strategic focus for collecting, and a failure to collect items when they were readily available.

The Queensland Museum is currently dealing with gaps in its collections and other issues through a new strategic plan that has been developed within the framework of the Queensland Government's priorities. New initiatives include the establishment of a collection management department; the adoption of a new collection management system; the consolidation of the Museum's collections into five major areas; and the establishment of a professional stream of collection managers.

The Queensland Art Gallery has developed its Acquisitions Policy 2001–05 in line with the $260 million Millennium Arts Project and the development of the new Queensland Gallery of Modern Art. The policy will deal with gaps in the Queensland Heritage collection.

Local government

The Australian Bureau of Statistics has reported on local government expenditure on environmental protection by state since 1998–99 (Trewin 2000, 2001, 2002). Local government expenditure on both biodiversity and cultural heritage appears to be increasing, although capital expenditure appears to be variable (table 9.29).

Table 9.29 Local government expenditure on biodiversity and cultural heritage ($ million)

Expenditure type	1998–99		1999–2000		2000–01	
	Biodiversity and landscape	Cultural heritage	Biodiversity and conservation	Cultural heritage	Biodiversity and conservation	Cultural heritage
Current	19.1	n/a	29.6	2.1	30.9	3.3
Capital	13.2	n/a	32.1	0.1	12.6	1.3
Total	**32.3**	**n/a**	**61.7**	**2.2**	**43.5**	**4.6**

n/a = not available

Sources: Trewin 2000, 2001, 2002

Thirteen of the 88 LGAs that responded to the EPA's survey of local government reported that they administer grants programs that provide support for heritage-related projects. Brisbane City Council, for example, provides financial assistance to individuals, community groups or organisations for projects that enhance community knowledge and understanding of Brisbane's history and cultural heritage through a local history grants scheme.

LGAs also provide widespread support for local museums. Sixty-five respondents to the survey (74%) had given support to local historical societies and museums since 1998. The nature of the support varied from direct funding to provision of a building, maintenance and other aspects, such as rates relief and insurance.



Local governments and local community groups and historical societies provide support to local museums throughout Queensland. Bundaberg Historical Museum displays the history and heritage of Bundaberg and its people. (Photo: Tourism Queensland)

Some LGAs also operate heritage advisory services. The Heritage Advisory Service, a state government initiative introduced before 1998, was intended to help local governments play a larger part in the management of historical cultural heritage within their jurisdictions. Local government heritage advisers provide advice, guidance and training for local governments, normally through a heritage advisory committee, which has local government and community representatives. Heritage advisory services have operated in Charters Towers, Gold Coast, Ipswich, Maryborough, Mackay, Toowoomba, Townsville and Warwick/Clifton.



The Government Bond Store in Maryborough, one of the earliest brick buildings in the town, was constructed in several stages from 1863, and now houses the Bond Store Heritage Museum. (Photo: Tourism Queensland)

The scheme was designed to be a temporary facility (three years per local government authority) focused on the development of procedures and processes. It was envisaged that participating local governments would continue to run their own advisory services as part of their heritage management programs.

Indigenous involvement in heritage management

Protection of heritage requires recognition of the relationship of Indigenous people to heritage places and objects, and the involvement of Indigenous people in their management. This requires laws, policies and agreements that undo the historical process of alienation of Indigenous people from their land, and concrete measures to give control of heritage places back to their Traditional Owners. Queensland legislation with relevance to Indigenous involvement in land and natural heritage management includes:

- *Local Government (Aboriginal Lands) Act 1978*;
- *Aboriginal and Torres Strait Islanders (Land Holding) Act 1985*;
- *Cultural Record (Landscapes Queensland and Queensland Estate) Act 1987*;
- *Aboriginal Land Act 1991*;
- *Torres Strait Islander Land Act 1991*;
- *Nature Conservation Act 1992*;
- *Native Title (Queensland) Act 1993*;
- *Wet Tropics World Heritage Protection and Management Act 1993*; and
- *Nature Conservation Regulations 1994—Special provisions relating to Aboriginal Tradition and Island Custom in Protected Areas*.

The recognition of native title rights, with the associated recognition of the rights of Indigenous people to have a say in the management of heritage places, has had major implications for the management of heritage. Indigenous involvement in natural heritage is examined below.
(See also page 9.47.)

Incorporating Indigenous perspectives in natural heritage management

Recognition of the significance of Indigenous values to understanding of natural heritage is growing, both within Australia and internationally. For instance, one of the aims of the International Convention on Biological Diversity (UNEP-CBD 1992), to which Australia is a signatory, deals with the rights and interests of Indigenous people in heritage management. Article 8(j) aims to:

> 'Subject to its national legislation, respect, preserve and maintain knowledge, innovations and practices of indigenous and local communities embodying traditional lifestyles relevant for the conservation and sustainable use of biological diversity and promote their wider application with the approval and involvement of the holders of such knowledge, innovations and practices and encourage the equitable sharing of the benefits arising from the utilization of such knowledge, innovations and practices;...'

Under this convention, Indigenous input is being sought at an international level to develop Indigenous perspectives on management of biodiversity.

Within the Australian context, the *National Objectives and Targets for Biodiversity Conservation 2001–2005* require that ethnobiological knowledge be maintained and recorded. The objectives include set targets to be achieved over the period and performance indicators to be evaluated in the national state of the environment report.



Indigenous guides lead tours through tropical rainforest in Mossman, far north Queensland. (Photo: Tourism Queensland)

Indigenous management of heritage areas in Queensland

A number of steps have been taken to develop partnerships with Indigenous communities in the management of protected areas in Queensland.

While some of Australia's World Heritage areas have been listed for both natural and cultural features, Queensland's World Heritage sites have been listed for natural values only. Traditional Owners of land within the Wet Tropics World Heritage Area have been lobbying for the Wet Tropics to be listed for its cultural values as well as its natural values (as is the case with Uluru and Kakadu national parks). The Cooperative Research Centre (CRC) for Tropical Rainforest Ecology and Management (CRC Rainforest 2002) recognises that:

> 'The rainforest is a complex system of living Aboriginal cultures. Cultural sustainability of the rainforest recognises and respects Indigenous peoples' prior ownership and knowledge of the rainforest incorporating land management and environmental knowledge, language and social structures. Culturally sustainable management of rainforest is a two-way street with land management agencies having obligations to Aboriginal people to protect cultural heritage and Aboriginal people having land management responsibilities to their country. There exists a direct interrelationship between the cultural sustainability of the rainforest and its ecological and economic sustainability.'

A range of measures involve Traditional Owners in management of the Wet Tropics World Heritage Area. The Interim Negotiating Forum agreed to by the Wet Tropics Management Authority (WTMA) and the North Queensland Land Council aims to establish a regional agreement with the rainforest Aboriginal peoples. Examples of the developing relationship with the Traditional Owners and state agencies include:

- an increase in the area of land under formal Indigenous management, from 13 066 ha in 1992 to 26 453 ha in 2002. This includes a cooperative management agreement with the Djabugay Tribal Aboriginal Corporation for Mona Mona and one native title determination over seven hectares (WTMA 2002);
- the development of cultural indicators to assist in management (Smyth and Beeron 2001), which will be reported in the *State of the Wet Tropics Report*;
- the opening of the Nganyaji Interpretive Centre in Ravenshoe (Kennedy 2002; see 'Nganyaji, a new interpretive centre for the Jirrbal people', page 9.45);
- the development of research partnerships through the Rainforest CRC; and
- the employment of three community liaison officers.

Native title and heritage

The recognition of native title rights by the High Court of Australia presented an opportunity for traditional owners to gain certain rights over their traditional areas, which may include recognised heritage areas, including World Heritage and state protected areas.

There have been twenty determinations of native title out of 399 registered applications in Queensland. These include the Mabo decision of 1992. Since 1999, 194 native title claims have been made. All determinations of native title except the Mabo decision were by consent or unopposed. Ten of the claims were resolved in 2000 and 2001, and dealt with land in the Torres Strait islands.

No determinations have been made for claims over protected areas. Within the native title framework there is provision for Indigenous Land Use Agreements (ILUAs) between native title groups and other parties. At the end of 2002, there were 40 ILUAs in Queensland, although none of these was with the EPA or the QPWS (National Native Title Tribunal 2002). An ILUA between the Wet Tropics Management Authority and Traditional Owners has been proposed.

Indigenous management in state protected areas

Under the *Aboriginal Land Act 1991* and the *Torres Strait Islander Land Act 1991*, 14 national parks were deemed claimable by Traditional Owners, subject to leaseback arrangements to the state. Since 1998, claims for a further three parks have had hearings completed, bringing the number of completed hearings to eight. While six of the claims have received ministerial acceptance, no park has yet been returned to the Traditional Owners, as leaseback issues have yet to be resolved.

Within QPWS there have been a number of initiatives that embrace Indigenous values. Since 1999, there have been discussions in north Queensland between QPWS and Traditional Owners on a number of issues aimed at enhancing Traditional Owners' involvement in the management of protected areas. These include:

- adopting Indigenous language names for parks and for significant places on parks;
- developing hunting strategies and management plans for native species;
- developing outstations on traditional lands;
- concerns for protection of natural and cultural resources, by creating, for example, restricted access areas;
- planning issues on traditional lands;
- fire management issues on traditional lands;
- assistance in facilitating opportunities for the return to country of Traditional Owners (Flinders Island and Raine Island, for example);
- training opportunities, such as facilitating the involvement of Aboriginal rangers in fire training; and
- track maintenance or re-routing on parks.

On Flinders Island National Park, Traditional Owners have been involved in a number of projects and management functions including general operations, planning and design of infrastructure, fire management, walking track design and maintenance, capital works programs, and cultural site identification and mapping.

As part of the development of the Misty Mountains section of the Great Walks of Queensland, QPWS has consulted with Traditional Owners as cooperative managers in this project, with assistance from senior rangers, community liaison officers and the North Queensland Land Council (NQLC). Traditional Owners have also been employed to work on the cultural heritage trail and will play a major role in continuing maintenance and the preparation of visitor management plans for the project.

In central Queensland, a Traditional Owner reference group has been established for the Carnarvon National Park, while in southern Queensland, Quandamooka Land Council and QPWS have agreed to a protocol for the treatment of dead dugongs and turtles. Management guidelines have also been prepared for the traditional hunting of turtles within Quandamooka waters.

Other programs have begun to recognise Indigenous values in the management of protected areas. Land protected under community conservation schemes acknowledges both cultural and natural values. For example, the managers of the cattle property Marion Downs, which participates in the Land for Wildlife program, have also taken action to protect cultural heritage sites on the station. At October 2002, five of Queensland's 87 gazetted nature refuges were listed for their cultural and aesthetic values as well as natural values, and the Illmargini Nature Refuge in central Queensland specifically ensures access rights to Traditional Owners.

Indigenous staff employed in heritage management

As the process of incorporating Indigenous perspectives on heritage unfolds, a measure of Indigenous involvement is the employment of Indigenous people in heritage management.

The EPA has developed an Aboriginal and Torres Strait Islander Employment and Development strategy, which amongst other things aims to foster long-term relations with Traditional Owners in the management of protected areas. A process for recruiting Traditional Owners to designated Indigenous ranger positions aims to select people with cultural knowledge of the protected areas on which they will be working. At the end of 2002, 35 full-time Indigenous employees and another 16 in casual and temporary positions were engaged in protected area management; they comprised approximately 3.7% of the Parks Division's total workforce. Within the EPA a number of other Indigenous employees are in roles that have a heritage management component, such as Indigenous liaison and Indigenous planning.

The results of the survey of local government undertaken by the EPA for this report showed that only a small number of LGAs employ cultural heritage staff who identify as being Indigenous (table 9.30).

Table 9.30 Number of staff employed by local government in a cultural heritage role who identify as being Indigenous persons

No. of Indigenous staff	No. of LGAs
0	78
1	4
2	2
3	0
4	0
5+	0
No response	4
Total	**88**

Source: EPA 2002j

Indigenous language programs

The number and type of Indigenous language programs undertaken in Queensland provide a measure of the degree of support provided for the maintenance of Indigenous languages in this state. The Federation of Aboriginal and Torres Strait Islander Languages (FATSIL), established in 1991, is the national body for community-based Indigenous language programs in Australia. It aims to promote the maintenance, retrieval and revival of Indigenous languages through the support of community-based language programs. Although no comprehensive data about the number and type of language programs being undertaken in Queensland are available, FATSIL provides a directory of Indigenous language contacts and the types of programs and activities being undertaken (table 9.31). Funding for FATSIL from ATSIC budgets was $1.15 million in 2001–02, a significant increase on the $0.56 million in 1998–99.

Table 9.31 Examples of Queensland Indigenous language programs and activities

Organisation	Location	Activities
Ang-Gnarra Aboriginal Corporation	Laura	Teaching of Thypan language/culture by two fluent speaking Elders
Birri-Gubba Wadja Bimbi Aboriginal Corporation	Townsville—covering the coast from Ayr to Whitsunday and Proserpine, and inland areas	Introduction of Birri-Gubba language into schools, churches, youth groups and wider community. Production of animal language card games, dictionary book and storybook in Language and English
Cape York Indigenous Language Program	Hope Vale—covering the Cape York Peninsula	Promotion of Indigenous language in local schools. Production of a wide range of literature including stories, recipes and word lists. Production of audio/video cassettes and CD-ROM. Has retrieved and maintained 21 languages
Djabugay Tribal Aboriginal Corporation	Kuranda	Coordination of language programs and activities for the local Kuranda and Cairns communities, including lessons at Kuranda State School, Smithfield State High School and Cairns West State School
Kombumerri Aboriginal Corporation for Cultures	Beenleigh—covering the Goolburri and South East Queensland regions	Administration and distribution of Aboriginal and Torres Strait Islander Languages Initiatives Program (ATSILIP) grant funds for specific language projects. Management of Language ACCESS Initiatives Program to meet the needs of the Stolen Generation. Development of teaching materials, lessons, children's books, audio and video tapes for revival of languages no longer spoken fluently
Magani Malu Kes—Torres Strait Islander Language Consultative Committee	Townsville—covering all of Queensland	Projects include language classes, booklets, recorded songs, library resources, the Torres Strait Islander Language Kit on CD, booklet and cassette
Wondunna Aboriginal Corporation	Booral—covering central Queensland	Maintenance and revival of languages through the Central Queensland Aboriginal Language Program
Nalingu Cultural Centre and community members	Mitchell—covering Maranoa, Warrego, Condamine and Balonne regions of western Queensland	Teaching of lessons in language at local schools. Development of board games to use language and a range of teaching resources

Sources: FATSIL 2002b; Tjapukai 2002

Education Queensland (2002) carried out a review in 1999 of its education and employment programs for Aboriginal and Torres Strait Islander peoples, and released its Partners for Success Strategy in 2000. The strategy provides a framework for the improvement of education and employment outcomes for Aboriginal and Torres Strait Islander peoples, including encouraging schools in Queensland to work in partnership with their Indigenous communities.

Through this strategy, funding is directed to schools to develop school community-based Indigenous language programs. Fourteen schools, primarily in the Cairns, Cape York and Torres Strait districts, have developed such programs. Thirty-five other schools have implemented elements of community language programs within schooling practices. In conjunction with Aboriginal and Torres Strait Islander communities, Education Queensland has also developed Indigenous languages support materials to assist schools in community language programs. These materials outline suggested approaches for the retrieval and maintenance of Aboriginal languages and Torres Strait Islander languages. Since 1997, two schools on Cape York have also been involved in the development of pilot Indigenous Language Other Than English (LOTE) programs (D. Crump, Education Queensland, pers. comm.).

Responses

The indicators discussed in this section have all been response indicators. The effectiveness of management systems and funding applied to heritage protection will be assessed through changes in pressure indicators in future reporting cycles.

Summary of condition and trend indicators

Heritage protection

Indicator	Queensland
Funds allocated by government for the protection and conservation of natural heritage	▲
Funds allocated to Queensland Government agencies for the management of protected areas	▲
Proportion of natural heritage places with a management plan	▲
Funding allocated to Queensland Government agencies responsible for the protection and/or promotion of cultural heritage places	▼
Funding allocated to Queensland Government agencies responsible for the protection and/or promotion of cultural heritage collections	–
Funds and associated support provided by Queensland Government agencies to the community and local government for the maintenance, protection, conservation and promotion of cultural heritage places and collections	▼
Funds and associated support provided by government to small museums	?
Number of museums with collection policies	X
Number of state and local government agencies that have initiated and/or completed cultural heritage studies	X
Number of Indigenous people employed by government for the management and protection of Indigenous cultural heritage	▲
Number and type of Indigenous language programs undertaken in language centres, schools, and other institutions	X

Key to condition:

- Good
- Moderate
- Poor
- Not assessed

Key to trend:

- ▼ Decreasing
- ▲ Increasing
- ? Not clear
- X Not assessed
- – No change

Case study: Queensland Rail—recent cultural heritage achievements

In an effort to move towards self-regulation, Queensland Rail (QR) has completed a comprehensive survey of its cultural heritage assets. QR provides nominations of sites for entry in the Queensland Heritage Register (QHR), and develops strategies to ensure that nominated sites are given conservation priority. The following actions will enable QR to move further towards self-regulation:

- development of categories of conservation management action for application to all heritage-nominated assets;
- development of an electronic database for the management of its Heritage Asset Register;
- identification of officers within QR as heritage officers;
- establishment of a Heritage Committee, comprising representatives of most QR business groups and the EPA, which meets monthly to consider all heritage-related issues within QR operations;
- development of a checklist to enable sympathetic development works on heritage assets; and
- development of an internal publication entitled *Heritage Guidelines Kit* to guide QR personnel engaged in construction works, repairs and maintenance of heritage buildings.

Source: Scheuber 2002









Examples of railway heritage, clockwise from left: Normanton–Croydon railway line; Normanton Railway Terminus; rail bridge at Humphery, near Gayndah; Stoney Creek bridge, Cairns to Kuranda railway line (Photos: EPA)

Case study: Greenmount Homestead

Entered in the Queensland Heritage Register, Greenmount Homestead, via Walkerston, near Mackay, is of special significance to Queensland's cultural heritage. The 'collection' includes homestead buildings and grounds from the early 20th century and three generations of material from the Cook family.

The pressures facing Greenmount Homestead were identified in 1999 (EPA 1999a). The need to manage conservation requirements within a framework of maintaining heritage significance remains paramount.

Cyclical maintenance of buildings and grounds, and further cataloguing and conservation works, particularly of the material collection, are continuing pressures in the management and presentation of Greenmount.

Since 1999, planning and conservation works have been undertaken, funded predominantly by an $838 000 grant through the Centenary of Federation project. A memorandum of understanding between Mackay City Council and Mackay Historical Society outlines the partnership between the parties in Greenmount's ongoing management and operation.

A conservation management plan (CMP) and an interpretation plan have been developed to guide decision making into the future. Conservation works on the homestead, outbuildings and gardens were undertaken in accordance with the CMP.

A collection conservation needs assessment, works program, disaster management plan and cyclical maintenance program have been written, but have not yet been fully implemented. Non-Greenmount material has been removed from the homestead, while the volunteer-based Friends of Greenmount have received some training in preventive conservation.

Strategic planning, involving all stakeholders, has started on the preparation of an events calendar as well as research and conservation issues.

By Marianne Moss, EPA







Greenmount Homestead, near Mackay (from top): one of the many outbuildings of the homestead complex; the main house; farming machinery (Photos: EPA)

Case study: Yugambeh Museum

Cooperative relationships are being developed between the EPA's Cultural Heritage Branch and Indigenous communities and organisations. The Yugambeh Museum, Language and Heritage Research Centre at Beenleigh is now successfully operating its own register of important cultural heritage places. The register is the product of an extensive working relationship with the Cultural Heritage Branch that began in October 2000. Yugambeh community members, supported by a volunteer from The University of Queensland, have compiled and checked cultural heritage place information provided by the branch. Community members have also undertaken surveys with cultural heritage consultants and, as a result, the number of places entered in their register has doubled.

The Centre has customised the design of the register to include forms and reports that suit its needs. Yugambeh Museum's library collection, which includes books, videos and articles, has now been cross-referenced with the register entries. As well as providing additional photographs, the Cultural Heritage Branch has helped museum staff to develop a geographical information system (GIS). The Centre has now transferred database records of significant sites to this system to allow complete information management.

Source: EPA 2002h

Case study: Nganyaji, a new interpretive centre for the Jirrbal people

The traditional rainforest lifestyle of the Jirrbal people is being showcased in a new interpretive centre at Ravenshoe in tropical north Queensland, forming part of the Queensland Heritage Trails Network. The centre is located next to the Koombooloomba Wet Tropics World Heritage Area Visitors Centre. Jirrbal Elders chose the centre's name, Nganyaji, which means 'all of us together'.

The Jirrbal people were closely involved in planning for the project, which fulfils their long-held aspirations to present their cultural heritage to their own community and visitors to the region in a single location. The displays feature 'country' and 'Jujuba' creation time, telling the story of the establishment of Jirrbal lore and society; traditional lifestyles; community life; contact history; and, importantly, impressions of the Jirrbal people today.

One of the major aims of Nganyaji is to create an awareness that 'traditional' life is not something from the distant past, and that significant aspects of this lifestyle continue within the living memory of Jirrbal and non-Jirrbal community members. Many Jirrbal Elders remember traditional life and the cultural and personal impact of European settlement, and are fluent speakers of traditional language. Their passion for their traditional culture will encourage a sharing of cultures with visitors to the Nganyaji interpretive centre.

Source: MAQ and RGAQ 2002

Community awareness and support

Summary

Community awareness of and support for heritage are evident in the levels of public involvement in interest groups, heritage management, lobbying, and demand for heritage grants (see page 9.37). Community involvement in partnerships with government is a key, but under-used, component of heritage management. The community plays a pivotal role in the management of heritage and in lobbying all levels of government for improvements to heritage management practice in Queensland.

Increased community awareness of heritage issues may also improve heritage protection in regional and remote areas, where professional assistance is often limited. This has the potential to lead to improved identification of places and items significant to particular communities, and to help promote greater use of Indigenous languages.

Indigenous communities play an important role in the management of their heritage through involvement in heritage surveys and other site recording projects, and participation in the development of cultural heritage management plans, cultural centres, heritage database work and heritage tourism endeavours.

The Queensland community continues to support natural heritage issues through environmental community groups, of which the Queensland Conservation Council is the peak organisation. The National Trust of Queensland lists places and items of heritage significance, having over 1400 places listed at 30 June 2002. There is also a wide range of historical heritage community organisations throughout Queensland. While precise numbers of members of community-based heritage organisations are unknown, these bodies are a valuable resource for the management of heritage. Several heritage publications have been released to raise awareness of Queensland's heritage, promote the heritage tourism market and help communities in the operation of heritage places and collections.

The declining or unchanging levels of visitation at some heritage places represent pressures on their maintenance and long-term viability. The numbers of visitors to heritage places and collections are not being systematically collected.

An increasing trend towards devolution of responsibility for heritage matters from state to local government and community-based organisations has resulted in an increased demand for the expertise of private sector heritage professionals. Insufficient numbers of experienced heritage professionals in certain areas may influence the provision of adequate heritage protection and recognition for elements of Queensland's heritage. Cultural heritage professionals practising in Queensland have backgrounds in a range of heritage-related disciplines and are employed by a number of state government departments, collecting institutions, local governments and private consulting companies, or operate as sole traders. Anecdotal evidence from interstate and overseas indicates that the number of cultural heritage professionals is declining and that those currently practising lack certain skills. A range of natural and cultural heritage management education and training options is available, but specialised heritage training for architects and other built environment professionals is limited in Queensland.

The print and electronic media are important tools for increasing the level of community awareness of cultural heritage, particularly the transmission and use of Indigenous languages. Indigenous languages are being published in local newspapers and newsletters, and transmitted by radio and television, though the extent of this distribution is unclear.

The community plays a key role in the management of our heritage and in lobbying all levels of government for improvements to heritage management practice in Queensland. Community support is vital for the management of cultural heritage and appears to be an untapped opportunity to be developed.

Description

Measuring degrees of awareness of and support for heritage is difficult. We examine community groups' involvement in heritage management, numbers of visitors to heritage places and collecting institutions, and the number of heritage professionals and availability of professional training in Queensland, and investigate the involvement of the media in the promotion of heritage, in particular Indigenous languages. Indicators include:

- the number of community-based heritage organisations (both natural and cultural);
- the contribution of the National Trust of Queensland, including the number and type of heritage places it has listed;
- the nature and level of Indigenous community involvement in cultural heritage management;
- the number of Indigenous language media programs;
- the number of visitors to collecting institutions;
- the number of visitors to natural, Indigenous and historical heritage places; and
- the number of heritage management professionals practising in Queensland, and the type of training available to them.

Pressures

Visitors to heritage places and collections constitute a considerable pressure on the maintenance and long-term viability of such places. Heritage places that are open to visitation by the public are unlikely to be self-supporting ventures. Sustaining appropriate levels of funding is of major concern, as short-term programs and funding may have short-term benefits, but their sustainability is questionable. For example, many projects undertaken as part of the Queensland Heritage Trails Network program could not demonstrate the possibility of returning a profit, while the James Cook Museum in Cooktown, which represents a long-term heritage venture, was the only National Trust property to return a profit.

Income from entry fees provides only a small proportion of the funding required to meet the operating expenses of heritage places that are open to the public. For example, in 2001–02, admissions and tour fees at Newstead House in Brisbane constituted less than 17% of the total amount required to continue operations (EPA 2002b). The objective of increasing visitor numbers in order to increase income creates a pressure in itself. Increased visitor numbers may have impacts on the heritage significance of a place through measures taken

to make it a potential tourist attraction. Increased visitor numbers also have the potential to increase physical impacts on heritage places through accidental and intentional damage and extra wear and tear.

A reduction in the provision of heritage expertise and advice from government to heritage owners and managers is also a major pressure on the future management of heritage in Queensland. Increased responsibility is being placed on owners to seek professional advice from the private sector, a task traditionally performed by government heritage officers (see also 'State measures', page 9.35). There is a lack of cultural heritage expertise available to local governments, particularly in regional and remote areas (Horrigan and Buckley 2002). Without sufficient funds to employ professionals, these regions will fail to deal appropriately with heritage issues.

The lack of effective heritage training programs constitutes a potential pressure on the levels of support for Queensland's heritage. Although precise numbers of active heritage professionals and the availability of education and training opportunities for them have to date not been clearly identified, these will require future monitoring.

Condition and trends

Community involvement

Community groups can play a significant role in raising awareness of natural and cultural heritage and supporting its management. They can do this through public activity; through publications, newsletters and websites; and by lobbying government. Public concern for the protection of heritage can be expressed through organisations such as the National Trust and the Australian Conservation Foundation, as well as through local historical societies, Indigenous community groups and organisations, and local action groups. These groups provide a focus for community involvement in a wide range of activities, including the documentation of heritage places and collections and public education.

Indigenous communities

The involvement of Indigenous communities in heritage matters is essential for the formulation of the most appropriate regimes for the identification, management and monitoring of Indigenous heritage places. Levels of involvement are difficult to quantify, as this information is not systematically collected. However, Indigenous involvement in heritage is known to include:

- rock art recording projects;
- development of management plans for cultural heritage places that are open to tourists;
- establishing 'keeping places' or cultural centres;
- establishing site or place databases;
- setting up heritage tours, trails or walks;
- cultural heritage surveys and monitoring of country and particular developments under environmental impact assessment processes; and
- working in partnership with academic institutions on research projects (see 'The Palace art site complex', page 9.54).

Figures provided on levels of Indigenous community involvement are likely to substantially understate actual levels. The EPA has identified 21 Indigenous community groups currently involved in the management of cultural heritage projects. They include native title claimants and/or groups, Aboriginal corporations and cooperatives, Elders and reference groups, and other Traditional Owner groups. Projects used to report on this indicator were specifically non-development-related, and range from archaeological investigations of country to the repatriation of human remains (see 'The Riversleigh Archaeological Project', page 9.53).

Indigenous involvement in development-related cultural heritage projects can be measured to a large extent by the numbers of permits issued under the Cultural Record Act. Evidence of consultation and the subsequent involvement of Indigenous people is a requirement under the Act. In the 2001–02 financial year, 162 permits were issued (see figure 9.12, page 9.19).

Historical community groups

The many community organisations in Queensland involved in the management of historical cultural heritage include state or nationwide organisations, local historical societies, organisations assisting in the management of museums, lobby groups and genealogical societies. Although there is no comprehensive listing of these organisations, 86 had been identified at 30 June 2002. Unfortunately, membership numbers are not available.

The National Trust of Queensland is a peak community body involved in heritage management. Its mission is to 'identify, preserve and promote our heritage'. The Trust undertakes its mission by identifying places of significance through its heritage list, preserving particular places through ownership and management, and promoting heritage through lobbying, publications and special events. The Trust has 16 member branches throughout the state and four 'Friends' supporter groups, and at 30 June 2002 had over 10 000 members. Membership has grown steadily from 5855 members in 1991–92. According to the Trust's 2001–02 annual report, about 250 of those members are active Trust volunteers.

The Trust also maintains a list of places and items of heritage significance, including a list of places under threat (see 'The National Trust's Endangered Places List', page 9.54). Although the list has no legal effect, it is used as a tool for raising awareness of and lobbying for improvements to the management of places and items of significance. This list has grown steadily since 1999, when 1384 places were reported, to 1424 places at 30 June 2002. About 21 additional listings have been made each year since 1995–96. It should be noted, however, that due to the National Trust being largely a volunteer organisation, the focus of listings can shift depending upon members' interests, and growth can be irregular.

Like the Register of the National Estate, the Trust's heritage list includes natural, Indigenous and historical heritage places. Past inconsistencies in the recording and categorising of places make it difficult to compare the Trust's list with the Queensland Heritage Register. The Trust is currently redeveloping its listings database. This will enable consistency

of recording so that better comparisons can be drawn in the future. The list does, however, contain types of historical places that are either not included or represented differently in the Queensland Heritage Register (table 9.32). While the Queensland Heritage Register includes some trees of heritage significance, the Trust list contains many more. The Trust list also includes an item of moveable heritage.

Table 9.32 Number and proportion of some place types on the National Trust heritage list

Place type	Number of listings	Percentage of total listings
Trees	95	6.7
Precincts	60	4.2
Indigenous heritage places	4	0.3
Natural heritage places	198	13.9

Source: National Trust

The Trust holds an annual heritage festival. In 2002, 89 events were held over nine days throughout Queensland. During the festival, the annual John Herbert Awards are presented in recognition of excellence in heritage conservation. A record 48 entries were received for the awards in 2001–02.

Environmental community groups

Concerns about the degradation of our natural heritage have become a major issue for many people, gaining significant media attention and stimulating political debate and participation in community environmental organisations. Our increasingly urbanised population participates in the protection of our heritage by joining or supporting environmental organisations.

The Queensland Conservation Council is the peak organisation for conservation groups in Queensland working for the protection and promotion of Australia's natural environment and biodiversity. In 1999–2000 the Council had over 50 affiliate organisations, over 250 individual supporters, and over 70 volunteers (QCC 2000). The affiliate organisations are concerned with both local and statewide environmental issues.

Although there is no comprehensive directory of environmental groups for Queensland, 112 groups have been identified in consultation with the Queensland Conservation Council. Data on the membership levels for each of these groups are not available. Groups are likely to range in size from a small number of individuals to much larger memberships, such as the Kuranda Envirocare Group, which has over 200 members.

Visiting heritage places and collections

The number of people visiting heritage places and collecting institutions is a measure of the community's awareness of and support for natural and cultural heritage, whether the visitors are local, from interstate or from overseas. However, visitation also constitutes a pressure on heritage places and is an important consideration in their management (see page 9.20).

Increasing visitation to Indigenous rock art sites may indicate greater awareness and support, but also brings greater risks of damage and vandalism. Rock art sites are often in remote locations, and the management of visitors and measurement of visitor numbers can be difficult. However, such information is important in the formulation of decisions on management and monitoring of heritage sites (Jacobs and Gale 1994).

The installation of visitor books at some cultural heritage places in Queensland is providing a measure of visitor numbers, but their accuracy is limited because not all visitors sign the book (Jacobs and Gale 1994). Recent research at Laura in far north Queensland and in the Grampians in Victoria has shown that about 20–30% of visitors to cultural heritage places sign the visitor book, providing some guidance for the extrapolation of data (Buhrich 2002; Franklin 2000; Gunn 2001; Lawie 2001).

The visitor books at two Queensland Indigenous rock art sites—Split Rock in the Laura region, and Ship Shelter on Stanley Island in the Flinders Group National Park—have been partly analysed for information about visitor numbers. Although visitor books have also been installed at rock art sites in Carnarvon National Park (Carnarvon Gorge and Mt Moffatt sections), Boodjamulla (Lawn Hill) National Park and Chillagoe/Mungana Caves National Park, their contents have not yet been analysed and no program is in place to analyse them in the future.

The public has known of Split Rock since the early 1960s and visitation to the site is likely to have been quite low well into the 1970s. However, entries in visitor books indicate that visitor numbers have been steadily increasing since 1987. Annual visitor numbers have been estimated at between 4300 and 6400 in 1987 to between 7900 and 11 900 in 1999. The range in visitor numbers has been estimated by assuming that the number of entries in the visitor books represents about 20–30% of the actual number of visitors (Cole and Horsfall 2002). The analysis of the visitor books has also shown that visitation to Split Rock is markedly seasonal. Most visits occur during the dry season from June to September, and numbers are lower in October to December. More international visitors come later in the season (September to November), while Australian visitor numbers peak around July (Rowland and Franklin 1992; Sullivan 1992).

Visitor books have been installed at Ship Shelter since 1986, but trends in visitor numbers cannot be assessed, as only entries made since 2000 have been analysed. However, a seasonal pattern of visitation is also apparent here, with indications that about 85% of annual visits occur between June and December (A. Davies, pers. comm.).

Like most Indigenous sites of significance, many historical and natural heritage sites are in remote and isolated locations. Entrance fees charged at some provide an accurate means of measuring visitation levels. Visitor numbers at places where no entrance fee is charged are recorded or estimated using a range of techniques. A sample of heritage places and collecting institutions where visitor numbers have been recorded or estimated is shown in table 9.33. The table demonstrates a range of visitor trends.

The Queensland Heritage Trails Network projects—the Blackall Woolscour and the Qantas Founders Museum at Longreach—show how increasing visitor numbers can correlate with recent capital works and opening celebrations. In only four months after July 2002, visitor numbers to the Qantas Founders Museum reached 18 138. Review of the levels of visitation will be important in assessing the sustainability of these increases.

Redevelopment of heritage places can also cause visitor numbers to fall. The Museum of Tropical Queensland in Townsville experienced a decline in visitor numbers in 1999–2000 as a result of redevelopment and expansion works.

Table 9.33 Number of visitors to heritage places and collecting institutions by financial year, 1996–97 to 2001–02, and overall trend

Place/institution	1996–97	1997–98	1998–99	1999–2000	2000–01	2001–02	Overall trend
Blackall Woolscour	n/a	n/a	8 111	7 427	6 325	7 431	▲
Chillagoe/Mungana Caves National Park	15 542	15 198	16 883	14 369	14 118	13 683	▼
Fort Lytton National Park	~6 000	~6 000	~6 000	~6 000	~6 000	~4 000	▼
*Gothenburg**	15	15	28	4	5	n/a	▼
Newstead House	18 232	13 528	11 121	11 959	10 153	8 806	▼
Qantas Founders Museum, Longreach	n/a	n/a	25 180	24 739	19 618	24 914	▲
Queensland Maritime Museum	n/a	n/a	23 425	24 200	20 532	26 584	▲
Queensland Museum (all campuses)	771 845	754 152	676 778	556 114	609 914	625 477	▼
Queensland State Archives	9 815	9 470	9 892	9 697	9 433	8 768	▼
St Helena Island National Park	~15 300	~19 500	~17 400	~21 500	n/a	19 196	–
*Yongala**	3 866	5 316	4 742	4 857	6 748	n/a	▲

*Numbers are for calendar years. **Trend:** ▲ increasing; ▼ decreasing; – no change. n/a = not available

Sources: EPA; EPA 2002i; QHTN





Blackall Woolscour, Blackall, before and after the Queensland Heritage Trails Network project to redevelop the site for visitors. It is the only known surviving example of an early 20th-century mechanised woolscour in Australia. (Photos: EPA, top; Tourism Queensland, bottom)

Visitation levels to regional places other than Indigenous sites can also be seasonal. Most of the visits to the Blackall Woolscour occur between the months of April and October; visits in the months November–March account for only about 5% of the annual total.

Accessibility appears to affect levels of visitation to heritage places and collections. Estimates of the number of dives to historic shipwrecks other than the *Yongala* appear to be relatively constant or declining. The number of dives per year to the *Yongala*, measured by commercial operators' returns of the Environmental Management Charge to GBRMPA, increased between 1997 and 2001. The installation of moorings in July 2002 and consequent improvement in the accessibility of the *Yongala* is expected to increase the number of dives to around 10 000 a year (see figure 9.14, page 9.20).

The number of visitors to the Queensland Maritime Museum in Brisbane fell in 2000–01, then rose in the following year. This may be attributed to the construction of the Goodwill pedestrian bridge nearby; access to the museum was disrupted during construction but improved after the bridge was opened. The trend in visitor numbers for the Queensland Museum campuses can also be attributed in part to accessibility. For instance, the decline in 1999–2000 may be partly due to the construction of the Melbourne Street bus interchange, which influenced visitor numbers to the Queensland Museum. The declining trend in visitation to the Chillagoe/Mungana Caves National Park may be in part associated with the availability of air services to the region and changes to package tour itineraries.

The numbers of visitors to national parks in Queensland, as determined by the numbers of camping permits issued, remain steady. A selection of national parks with known visited cultural heritage sites and high-level natural heritage values have been assessed. These parks were Blackdown Tableland, Bladensburg, Cape Hillsborough, Carnarvon (Mount Moffatt section), Daintree, Diamantina, Girraween, Great Sandy, Hinchinbrook, Lamington, Lawn Hill, Lumholtz and Orpheus Island (table 9.34).

A range of trends for camping visitors to these parks has been identified. The numbers of visitors to Blackdown Tableland, Carnarvon (Mount Moffatt section), Diamantina, Lumholtz and Orpheus Island remained steady. Bladensburg, Daintree, Girraween and Great Sandy received increased numbers, while visitor numbers to Cape Hillsborough, Hinchinbrook, Lamington and Lawn Hill decreased. Visitor numbers to parks fluctuate over time, though overall time spent camping in parks is generally decreasing. This trend may be related to declining interest in visits to national parks, or it may reflect a shift in visitor preferences to other accommodation in the local area.

Table 9.34 Number of persons and person nights (camping) in selected national parks in Queensland by financial year

National park	1995–96		1996–97		1997–98		1998–99		1999–2000		2000–01	
	Persons	Person nights	Persons	Person nights	Persons	Person nights	Persons	Person nights	Persons	Person nights	Persons	Person nights
Blackdown Tableland	3 896	7 501	4 342	8 262	3 682	6 517	4 930	9 561	3 680	7 128	4 165	8 932
Bladensburg	0	0	0	0	78	102	198	263	435	544	269	225
Cape Hillsborough	2 219	5 471	1 662	4 868	1 643	4 845	1 504	3 351	1 490	3 746	207	592
Carnarvon (Mount Moffatt section)	805	1 789	1 124	2 656	731	1 908	928	2 372	1 200	2 976	1 020	2 523
Daintree	3 598	5 465	4 270	6 072	4 337	5 910	4 362	6 086	4 615	6 465	4 872	6 918
Diamantina	283	538	294	579	424	1 017	434	743	731	1 299	606	1 159
Girraween	11 388	27 266	12 798	29 903	11 772	27 966	13 964	32 459	12 290	29 234	12 955	32 774
Great Sandy	30 954	70 535	29 271	67 797	25 477	57 912	29 955	68 938	26 203	58 613	33 552	67 795
Hinchinbrook	4 979	16 835	4 480	15 877	4 371	15 994	4 332	16 310	4 573	17 454	3 379	12 367
Lamington	10 047	21 762	9 423	19 012	8 005	15 010	7 263	13 503	7 246	13 993	8 041	14 572
Lawn Hill	8 054	20 553	7 035	18 851	6 149	16 665	6 720	17 672	6 194	15 881	2 829	7 758
Lumholtz	1 164	1 439	1 101	1 457	1 007	1 282	926	1 095	891	1 086	1 034	1 282
Orpheus Island	492	1 347	294	1 000	332	1 264	256	1 243	229	810	211	681
Total	**77 879**	**180 501**	**76 094**	**176 334**	**68 008**	**156 392**	**75 772**	**173 596**	**69 777**	**159 229**	**73 140**	**157 578**

Source: EPA

Data for day visitors to national parks are not available. However, data compiled from international and national visitor surveys conducted during 1999–2000 and provided by the Bureau of Tourism Research Australia indicated that over 1.1 million international visitors to Queensland visited national parks. In 2001, surveys of domestic visitation levels indicated that 992 000 Australians visited Queensland's national parks. A QPWS survey commissioned in 1999 (ACNielsen 2000) showed that 81% of Queenslanders had visited a national park, and 45% had visited one in the previous 12 months. Those surveyed believed that park areas provide a wide range of positive benefits, the most positive being the protection and preservation of Queensland's natural heritage (ACNielsen 2000).

Heritage professionals and training

The numbers of heritage professionals and the level of training available to them are an indication of the support available to communities for the management of heritage places and collections. The wide diversity of natural heritage professionals, including those qualified in disciplines such as biology and zoology, makes this area difficult to measure.

Cultural heritage professionals

Cultural heritage professionals have backgrounds in a wide variety of disciplines including cultural heritage management, heritage architecture, Indigenous and historical archaeology, anthropology and environmental management. Although there is no comprehensive listing of heritage professionals, the EPA maintains lists of cultural heritage professionals currently working in Queensland. In the fields of both historical and Indigenous cultural heritage, these professionals are mainly sole traders, although some work in organisations consisting of a small number of professionals. At 30 June 2002, there were 20 individuals or organisations in Queensland whose expertise is predominantly in historical heritage. They are mostly concentrated in the south-east corner of the state. Forty-eight individuals or organisations with expertise predominantly in the field of Indigenous heritage management were listed. Indigenous heritage professionals were more evenly distributed throughout the state than those working in historical heritage (table 9.35).

Cultural heritage professionals belong to a number of statewide and national professional organisations (table 9.36). Membership of Australia ICOMOS, the Australian Association of Consulting Archaeologists and the Professional Historians Association (Qld) requires professional qualifications and/or experience in the heritage field. The remaining organisations are open to both professional members and other interested persons. Most national organisations maintain Queensland memberships at around 10% of the national total, apart from the Australian Archaeological Association (AAA), which has 31.3% of its membership in Queensland. This may be explained in part by the fact that the current executive committee is resident in Queensland and that a membership drive took place in the first half of 2002.

A range of state government departments and agencies employ professional staff in a cultural heritage role. As lead agency for cultural heritage in Queensland, the EPA employs 40 cultural heritage staff in offices in Brisbane, Toowoomba, Rockhampton, Townsville and Cairns. QPWS employs one cultural heritage officer in Brisbane. Other state government agencies that employ cultural heritage officers include the Department of Main Roads, the Department of Primary Industries, the Department of Public Works, Queensland Rail and Queensland Health.

Table 9.35 Number and distribution of cultural heritage professionals practising in Queensland, based on EPA contact lists

Location	Number of professionals			
	Heritage Act	Percentage	Cultural Record Act	Percentage
Southern Queensland	18	90	24	50
Central Queensland	0	0	4	8
North Queensland	2	10	8	17
Interstate	0	0	12	25
Total	**20**	**100**	**48**	**100**

Source: EPA

Table 9.36 Number of cultural heritage professionals belonging to professional organisations, including proportion of national membership, at 30 June 2002

Organisation	Queensland members	Total members	Percentage of total members
Australia ICOMOS	36	414	8.7
Australian Archaeological Association	153	489	31.3
Australian Association of Consulting Archaeologists	7	84	8.3
Australasian Society for Historical Archaeology	30	294	10.2
Australian Institute of Marine Archaeology	33	~200	~16
Professional Historians Association (Qld)[a]	92	389[b]	23.7

[a] Members at December 2002

[b] This figure represents the number of members in the Australian Council of Professional Historians Associations, to which the Professional Historians Association (Qld) is affiliated.

Four major state collecting institutions (Queensland Museum and campuses, Queensland Art Gallery, John Oxley Library and Queensland State Archives) were surveyed regarding numbers of staff employed in a cultural heritage capacity. At 30 June 2002, these institutions employed a total of 25 conservators (full-time and part-time) (see table 9.18 on page 9.24 for details). The Queensland Museum employed 16 persons (including curators, conservators and collection managers) in its Cultural Heritage Program.

Local government authorities were also surveyed about employees whose duties primarily involve cultural heritage, and how many of those identified as being Indigenous. Sixty of the 88 respondent local governments indicated that they had no employees whose primary duties were related to cultural heritage. Fifteen local governments employ one person, while only five employ five or more staff in a cultural heritage capacity. Local governments in total employ 59 persons whose duties involve cultural heritage. Only a small number of local governments employ cultural heritage staff who identify as being Indigenous: four employ one Indigenous person, and two employ two Indigenous persons (see table 9.30, page 9.41).

As the number of cultural heritage professionals is a new indicator for this report, it is difficult to identify definite trends. Anecdotal evidence and indications from interstate and overseas suggest that the level of cultural heritage professionals is declining and there is a skills shortage. These issues will be assessed in future reporting cycles.

Heritage education and training

Training of heritage place and collections managers is an important issue to consider when assessing the condition of Queensland's heritage. Specialist skills and knowledge are often required to determine appropriate conservation, protection and management strategies for particular places and collections.

In the 2003 academic year, 29 environmental management courses at the bachelor degree-level including natural and/or cultural heritage management training were offered by Queensland universities (EA 2002b). A review of tertiary courses offered through the Queensland Tertiary Admissions Centre (QTAC) identified 26 undergraduate-level courses across cultural heritage management-related fields such as history, cultural studies, anthropology, archaeology, cultural heritage management, cultural tourism management, protected area management, Aboriginal and Torres Strait Islander Studies and linguistics. The education opportunities for heritage training related to built heritage are less abundant. Heritage management constitutes only a small component of undergraduate courses in architecture and interior design offered by Queensland universities. Some trade-specific courses, such as the traditional plasterwork course at Yeronga TAFE, also include aspects of heritage building conservation and management.

Several universities offer postgraduate-level studies in cultural and natural heritage-related fields. James Cook University in north Queensland offers postgraduate certificate and masters-level studies in cultural heritage that are aimed at providing professional training. Similarly, the University of New England offers diploma and graduate diploma courses in archaeological heritage and archaeology. The University of Queensland offers graduate diploma and masters-level studies in protected area management that include exposure to both natural and cultural heritage management issues.

Cultural heritage professionals working in Queensland often undertake specialist training outside the state. Postgraduate courses undertaken include cultural heritage and museum studies at Deakin University in Melbourne, and heritage conservation programs through the University of Sydney. Summer school programs in cultural heritage management have also been offered regularly at the University of Canberra.

Programs in cultural heritage studies and conservation of heritage materials at the University of Canberra were suspended for 2003, but the university planned to approach key cultural institutions for donations to reinstate these courses (Jackson 2002). Queensland professionals have also participated in overseas programs including those offered at the Institute of Advanced Architectural Studies at the University of York in the United Kingdom.

Collecting institutions have identified a need for better professional development through better access to training for staff (Deakin University 2002). Major collections require staff to learn new skills to meet changing work environments, and to refresh expert knowledge after long periods working in the same discipline. The types of training required include staff exchanges, workshops, short courses and internships. Archives reported a decline in the number of trained archivists due to the reduction of tertiary-level training courses. Galleries also reported a shortage of trained registrars.

Indigenous languages in the media

The print and electronic media are important tools for increasing the level of community awareness of cultural heritage. In particular, they are a vehicle for the promotion of Indigenous culture and the continuing use of Indigenous languages. Currently, Indigenous languages are disseminated through radio, television, the Internet and the print media.

Indigenous print media include newspapers with a national focus, such as the *Koori Mail* and *Land Rights News*, which are widely available to communities throughout Queensland, as well as local community-based newsletters in Indigenous languages. Quantifiable data on the number of articles published in Indigenous languages are not currently available.

Quantifiable data on the amount of Indigenous language use in electronic broadcast media are also not available. However, radio licences have been issued to community groups for the purpose of broadcasting Indigenous content. Television and radio broadcasts in Indigenous languages occur largely at the level of small community and local stations (Lennon et al. 2001).

The National Indigenous Radio Service (NIRS) provides relevant Indigenous broadcasting from and to existing Indigenous radio stations and community radio stations, including over 100 Broadcasting to Remote Aboriginal Community Scheme (BRACS) units across Australia. Transmitting 24 hours a day from a hub station in Brisbane, the service provides a supplement to local and regional programming. It combines content from existing Indigenous radio stations around the country, including Queensland stations 4AAA Brisbane, 4K1G Townsville and 4C1M Cairns. Thirty-nine stations in Queensland are currently part of the NIRS network. No data on the level of content broadcast in Indigenous languages over NIRS are available, but there is a great potential for Indigenous languages to be broadcast using the existing infrastructure.

Numerous Internet sites promote Indigenous languages. These projects are often funded through grants from the Australian Institute of Aboriginal and Torres Strait Islander Studies (AIATSIS) or the Aboriginal and Torres Strait Islander Commission (ATSIC). (See pages 9.41–42 for information on Indigenous language programs.) The Aboriginal Languages of Australia website (Nathan 2002) provides the most comprehensive information concerning Australia's Indigenous languages. A total of 20 websites are listed that provide resources about Indigenous languages in Queensland.

Responses

The EPA publishes a range of information sheets to help raise awareness of cultural heritage issues within the wider community. Ten sheets have been published since 2001 on issues such as what comprises cultural heritage, making changes to heritage places, Indigenous heritage places, women and heritage, and multicultural heritage. They have been distributed to local governments and interested community groups, and are available from EPA offices.

The EPA has also released several publications to promote the growing heritage tourism market in Queensland. *North Queensland's Mining Heritage Trails* is a guide to the historic mines and mining towns of the state's north (EPA 1998). A series of regional heritage trail guides followed this book:

- *Heritage Trails of the Great South East* explores more than 500 heritage places throughout south-east Queensland, covering an area extending from Coolangatta to the Cooloola Coast and westward to the Darling Downs (EPA 2000a);
- *Heritage Trails of the Tropical North* presents heritage places in the Torres Strait islands and Cape York Peninsula, down through the tourism gateways of Cairns and Port Douglas, to the World Heritage-listed Bellenden Ker rainforests (EPA 2002e); and
- *Heritage Trails of the Queensland Outback* reveals the natural and cultural heritage found in Queensland's outback areas (EPA 2002f).

The Queensland Heritage Council also aims to raise awareness of heritage within the community, one of its strategic directions being to 'excite public interest'. It actively promotes heritage issues in the print media and on radio, and a standing item on its monthly meeting agenda is a review of heritage issues in the media. Since 2001, the Queensland Heritage Council has produced a quarterly newsletter, *Time and Place*, in partnership with the EPA. The newsletter is distributed free to local governments, libraries, owners of heritage places, and other interested members of the public, and has a circulation of approximately 2500.

The National Trust of Queensland is currently undergoing an important period of review in relation to its strategic direction for heritage in Queensland. As part of the review, it is assessing its property portfolio and how to best manage these places.

The Queensland Heritage Trails Network is a joint initiative funded by the Queensland and Commonwealth governments in partnership with local government authorities and local communities as part of the Centenary of Federation celebrations in 2001. This $110 million project aims to create a network of heritage places and attractions throughout regional Queensland and provide an opportunity for communities involved in heritage activities to support one another. Forty-three major projects across rural and regional Queensland have received funding to significantly upgrade and conserve existing cultural facilities or build new facilities (QHTN 2002a).

As a component of the initiative, the Network conducted a series of training courses in managing and operating attractions, managing volunteers, participating as a volunteer, tour guiding and interpretation, and museum skills. It released a training program, *Interpreting and Caring for Heritage Places and Collections*, on CD-ROM (QHTN 2002b), and a cultural heritage grants program was also offered (see page 9.37).

At the end of 2002, 22 of the 43 Queensland Heritage Trails Network projects had been completed, and several new attractions had been opened. The projects are expected to result in increased visitor numbers. Places that were formerly closed to the public, such as Glengallan Homestead near Warwick, have also been developed into heritage sites that will attract visitors.

Local governments in Queensland have an increasing role to play in encouraging greater community awareness of and support for heritage. They are already major supporters of local museums and heritage places (see page 9.39), and some are also undertaking surveys to identify places of cultural heritage significance to local communities (see page 9.15). In 2001, the EPA developed and distributed a set of cultural heritage management guidelines for local governments and communities. These *Guidelines for Cultural Heritage Management* (EPA 2001b) include information on identifying cultural heritage places, management mechanisms and relevant Commonwealth and state heritage legislation.

Summary of condition and trend indicators

Community involvement

Indicator	Trend/condition
Nature and level of Indigenous community involvement in cultural heritage management	X
Number and type of heritage places listed by the National Trust of Queensland	▲
Number of members of community-based heritage organisations	?
Number of visitors to Indigenous heritage places	?
Number of visitors to historical heritage places	?
Number of visitors to natural heritage places	?
Number of visitors to collecting institutions in Queensland	▼
Number of heritage management professionals practising in Queensland	▼
Types of tertiary-level training available to heritage management professionals practising in Queensland	X
Number of Indigenous language media programs	X

Key to condition:

Good

Moderate

Poor

Not assessed

Key to trend:

▼ Decreasing
▲ Increasing
? Not clear
X Not assessed
– No change

Case study: The Riversleigh Archaeological Project

The Riversleigh Archaeological Project is a joint venture between the Waanyi people, the EPA, the University of Sydney and the Australian Museum to document the cultural heritage values of this World Heritage-listed fossil site in north-west Queensland (see page 9.5).

As custodians of Riversleigh, the Waanyi people have been involved in the project since its inception. Excavations have yielded the remains of extinct megafauna, giant animals that may have survived until 20 000 years ago. Archaeological evidence suggests their coexistence with humans for at least 10 000 years. The Riversleigh Archaeological Project aims to investigate this coexistence further, and to determine what role humans may have played in the extinction of the megafauna.

The Queensland Government has implemented measures to protect and present the Riversleigh site, including the appointment of a full-time ranger, infrastructure upgrades and visitor signage to raise public awareness of the area's significance.

Source: EPA 2002d



Visitors guided at the Riversleigh site (Photo: Tourism Queensland)

Case study: The National Trust's Endangered Places List

Launched in 1998, the Australian Council of National Trusts' annual Endangered Places List is a response to community concerns that heritage places continue to be threatened despite legislative regimes existing throughout Australia. The launch provided an opportunity to enhance public understanding and appreciation of Australia's heritage, while at the same time allowing the National Trust to highlight concerns or impediments affecting conservation.

Although the list has no legal authority, it is increasingly effective in persuading the relevant authorities to respond to the concerns of the Trust and the community. The Trust also releases an Endangered Places Report Card each year, reporting on the places listed in the previous year's list. State and Territory National Trusts and community-based conservation groups are invited to nominate endangered natural and cultural heritage places for inclusion in the list. The list therefore provides a means for communities to voice their concerns about the threats facing the places they value in a nationwide context.

Four Queensland places were included in the Endangered Places List in 2002 (see page 9.24). The Petrie Terrace Police Depot and traditional Caloundra beach houses are of historical significance; Point Lookout is of Indigenous, historical and natural heritage significance; and Hinchinbrook Island and Passage are of natural heritage significance, being recognised as having World Heritage value.

At the top of the list is the category 'rural homestead', an inclusion of interest to Queensland as the state has a rich pastoral history.
Source: ACNT 2002







Queensland places on the National Trust's Endangered Places List 2002 (clockwise from left): Point Lookout, North Stradbroke Island; Petrie Terrace Police Depot, Brisbane; example of the Caloundra beach houses, Sunshine Coast. (Photos: National Trust)

Case study: The Palace art site complex

The Palace (formerly Blacks' Palace) is an internationally significant rock art and traditional burial site complex located in the Central Queensland Highlands. The complex has been heavily visited for at least the past 100 years, providing an example of visitor pressure on Queensland's remote Indigenous heritage (for further background information, see EPA 1999a).

A management committee was formed in July 1999 to oversee the review of the existing management plan for The Palace (Godwin 1992). The management committee consists of representatives from the Bidjara native title claimant groups, members of the local Bidjara community in Barcaldine, the EPA and DATSIP. The committee is examining various unresolved issues, such as a new name for the complex, the transfer of the existing reserve to Aboriginal trusteeship, conservation of the rock art and surrounding environment, and the management of tourism. The Palace currently remains closed to tourism.



Members of the management committee visiting the Palace art site (Photo: EPA)

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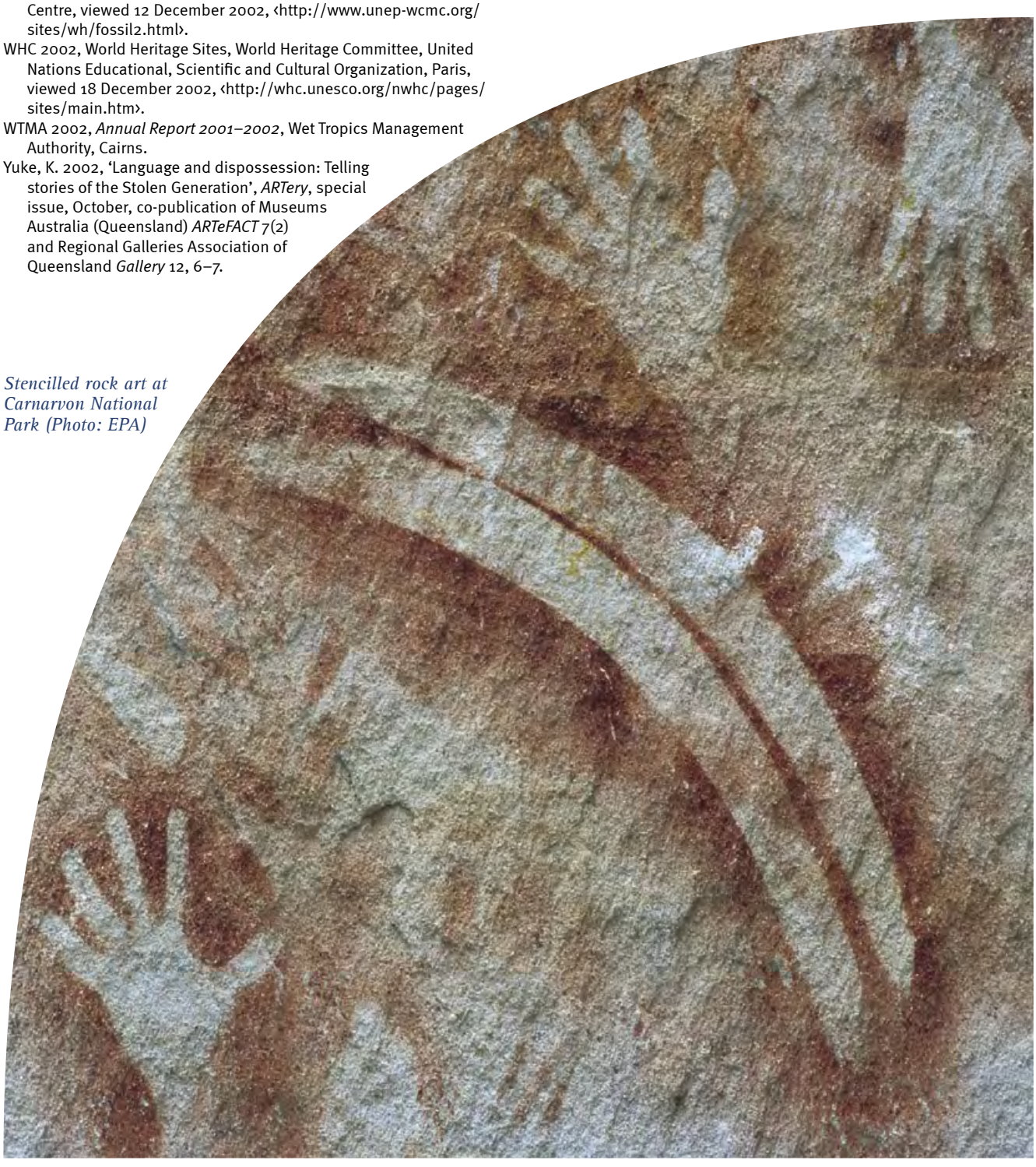
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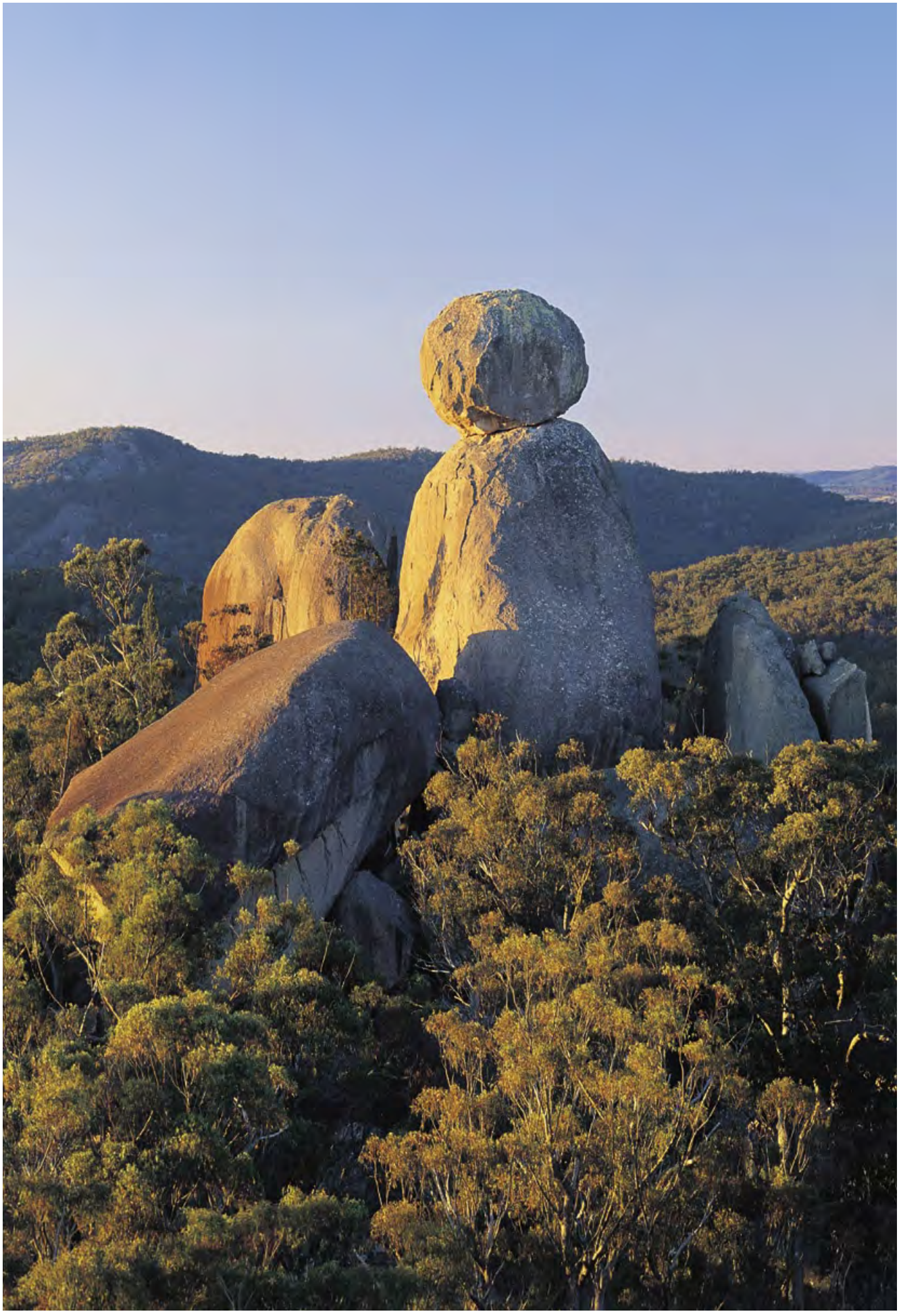
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Stencilled rock art at Carnarvon National Park (Photo: EPA)



The Sphinx, Girraween National Park (Photo: EPA)

Glossary

Units and measurement

µg microgram, a unit of weight equal to 10^{-6} grams

µm micrometre, a unit of length equal to 10^{-6} metres

µmol/L micro (10^{-6}) moles per litre

µS/cm microSiemens per centimetre. Siemens are a derived measure of electrical conductivity of a liquid.

cumec cubic metres per second, measure of water flow at a particular point

dS/m deciSiemens per metre

g gram, a unit of weight

gDW gram dry weight

Gg gigagram, a unit of weight equal to one thousand million (10^9) grams

GJ gigajoule, a unit of energy equal to one thousand million (10^9) joules

GL gigalitre, a unit of volume equal to one thousand million (10^9) litres

GW gigawatt, a unit of power equal to one thousand million (10^9) watts

GWh gigawatt hour, unit of electrical energy, equivalent to 3.6×10^{12} J

h or hr hour

ha hectare, a unit of area equivalent to 10 000 square metres. There are 100 ha in one **km²**.

hPa hectopascals, a measure of air pressure

J joule, unit of work and energy

kg kilogram, a unit of weight equal to one thousand (10^3) grams

KJ kilojoule, a unit of energy equal to one thousand (10^3) joules

KL kilolitre, a unit of volume equal to one thousand (10^3) litres

km kilometre, a unit of length equal to one thousand metres

km² square kilometre

KW kilowatt, a unit of power equal to one thousand (10^3) watts

kWh kilowatt hour, unit of electrical energy, equivalent to 3.6×10^6 J

L litre, a unit of volume

m metre, a unit of length

m² square metre

m³ cubic metre

mg milligram, a unit of weight equal to one thousandth (10^{-3}) of a gram

MJ megajoule, a unit of energy equal to one million (10^6) joules

mL millilitre, a unit of volume equal to one thousandth (10^{-3}) of a litre

ML megalitre, a unit of volume equal to one million (10^6) litres

mm millimetre, a unit of length equal to one thousandth (10^{-3}) of a metre

MW megawatt, a unit of power equal to one million (10^6) watts

MWh megawatt hour, unit of electrical energy, equivalent to 3.6×10^9 joules

ng nanogram, a unit of weight equal to 10^{-9} grams

nm nanometre, a unit of length equal to 10^{-9} metres

PJ petajoule, a unit of energy equal to one thousand million million (10^{15}) joules

ppb parts per billion

ppbv parts per billion by volume

ppm parts per million

ppmv parts per million by volume

ppt parts per trillion

R^2 a statistical measure used in regression analysis to describe the proportion of variation accounted for in a dependent variable by considering changes in the independent variable

s second

t tonne, a unit of weight equal to one million (10^6) grams

VKT vehicle kilometres travelled

W watt, a derived unit of power, defined as one joule per second

y or yr year

Glossary and abbreviations

AAA Australian Archaeological Association

AATSE Australian Academy of Technological Sciences and Engineering

ABARE Australian Bureau of Agricultural and Resource Economics

abiotic non-living, e.g. rocks

ABS Australian Bureau of Statistics

accessioning entering details of a specimen or an item into a catalogued collection

acid deposition the deposition on the Earth's surface, in either dry or wet form, of substances derived from natural and human-induced emissions of various compounds, especially those of sulfur and nitrogen, which have been transformed by chemical processes in the atmosphere

acid rain *see* **acid deposition**

acid sulfate soils soil or sediment containing highly acidic soil horizons or layers affected by the oxidation of iron sulfides (*actual acid sulfate soils*) and/or soil or sediment containing iron sulfides or other sulfidic material that has not been exposed to air and oxidised (*potential acid sulfate soils*)

ACNT Australian Council of National Trusts

administering authority an entity responsible for administration and enforcement of environmental strategies under the EP Act

ADR Australian design rule

AER agro-ecological region

aerosol a suspension of particles, other than water or ice, in the atmosphere and ranging in size from approximately 5 nm to larger than 10 µm in radius; may be either natural or caused by human activity. Most of the latter are usually considered to be pollutants.

AGL Australian Gas Light Company

AGO Australian Greenhouse Office

AIATSIS Australian Institute of Aboriginal and Torres Strait Islander Studies

AICCM Australian Institute for the Conservation of Cultural Material

air emissions inventory detailed listing of the estimated amount of emissions to the atmosphere by type and source over time and area

Air EPP *Environmental Protection (Air) Policy 1997*

Air NEPM National Environment Protection (Ambient Air Quality) Measure (1998)

air toxics a range of pollutants, mainly organic compounds, that cause or are suspected of causing long-term health effects in humans

AirWatch a school-based environmental education program focusing on issues affecting air quality

algal bloom a concentration of phytoplankton sufficient to impair water quality

ambient air surrounding outdoor air

amenity intangible environmental and social benefits such as peace and beauty

ANCA Australian Nature Conservation Agency

ANTA Australian National Training Authority

anthropogenic produced or caused by human activity *see also* **biogenic**

ANZECC Australian and New Zealand Environment and Conservation Council

ANZMEC Australian and New Zealand Minerals and Energy Council

APFD annual proportion of flow deviation

AQIS Australian Quarantine and Inspection Service

aquaculture the commercial culture of aquatic plants or animals in fresh or salt water

aquifer rock or sediment in a geological formation capable of being permeated so that it can transmit and store water *see* **groundwater**

arable suitable for crop production

arachnids a class of arthropods (segmented invertebrates having jointed legs) that includes the spiders, scorpions and mites

ARMCANZ Agriculture and Resource Management Council of Australia and New Zealand

artesian aquifer a water-bearing formation that, when it is tapped by a bore, shaft, well, gallery, spear or excavation, is subjected to hydrostatic pressure that allows the standing water level (or potentiometric level) to rise above the ground surface. An artesian aquifer is a completely saturated permeable formation of which the upper and lower boundaries are impervious layers.

ASEC Australian State of the Environment Committee

ASFB Australian Society for Fish Biology

ASGC Australian Standard Geographic Classification

assessment manager the body responsible for administering applications under the IP Act (in many cases, local government)

atmospheric inversion a condition occurring when a cool layer of air is trapped below a layer of warm air and is unable to rise

atrazine a selective systemic triazine herbicide absorbed principally through roots but also through foliage. Its mode of action is by inhibiting photosynthetic electron transport. It is persistent in soil, groundwater and surface water and special restrictions on its use apply in aquatic/riparian environments. It is very highly toxic to algae and aquatic macrophytes.

ATSI Aboriginal and Torres Strait Islander

ATSIC Aboriginal and Torres Strait Islander Commission

ATSILIP Aboriginal and Torres Strait Islander Languages Initiatives Program

AusAID Australian Agency for International Development, the Australian Government's official overseas aid program

AusRivAS Australian Rivers Assessment System

Aussie GRASS model a computerised spatial simulation of the condition of Queensland's grasslands developed through the Land and Water Resources Research and Development Corporation

Australian Height Datum (AHD) the datum used for the determination of elevations in Australia. The determination uses a national network of benchmarks and tide gauges, and sets mean sea level as zero elevation.

AWA Australian Water Association

AWQG Australian Water Quality Guidelines

background air quality the naturally occurring mixture of air in the absence of events such as fires

bagasse fibrous remains of sugarcane after juice extraction

ballast water water carried in tanks to maintain stability in a ship. It is normally discharged when the ship is loaded with cargo.

bare-surface farming system where vegetation is removed from soil surface between cropping or pasture growth cycles. Includes cropping where land is ploughed to bare soil after each harvest. Used principally for grains, oil seed, fodder crops and sugarcane.

baseline a specific time or defined area from which trends or changes can be assessed

BCC Brisbane City Council

BCM bromochloromethane

benthos marine organisms living on or in the sea floor

benzene a toxic chemical found in coal tar and cigarette smoke and used as an industrial solvent, as a petrol additive, and in some paints or varnishes; a known carcinogen

BHC benzene hexachloride

BHP Broken Hill Pty Ltd

bioavailability the ease with which a chemical is absorbed into plants or animals

biocides generic term to cover pesticides, insecticides, herbicides, fungicides

biodiversity the variety of all life forms: the different plants, animals and micro-organisms, the genes they contain and the ecosystems they form

biodiversity status the EPA assigns each regional ecosystem a conservation status. It takes into account the status assigned under the *Vegetation Management Act 1999*, which primarily looks at loss through clearing. It also takes into account the extent to which the regional ecosystem has been affected by other threatening processes such as loss of ground layer species composition from grazing pressure or loss of topsoil and long-term displacement of native species by weeds.

biogas fuel gas such as methane and carbon dioxide derived from the decay of organic matter

biogenic originating from the natural environment
see also **anthropogenic**

biogenic emissions emissions from natural sources including vegetation, soils and the ocean

biological control controlling a pest by the use of its natural enemies, for example, predators, parasites and disease-producing organisms

biomass total mass of an organism or organisms living in a particular areas, for example the biomass of all the trees, grasses and shrubs

biomass burning the combustion of waste organic matter such as stubble, **bagasse**

bioregion (biogeographic region) an extensive region distinguished from adjacent regions by its broad physical and biological characteristics

biosolids organic products from the treatment of sewage; also known as sewage sludge

biosphere the part of the Earth where living organisms are to be found

biota all the organisms in a given area

blue-green algae microscopic, photosynthetic aquatic organisms; term commonly used to represent **cyanobacteria**

BOD biochemical oxygen demand, a measure of the oxygen-depleting capacity of an **effluent** due to decomposition by micro-organisms

BoM Bureau of Meteorology

BP British Petroleum

BRD bycatch reduction device

broadacre (farming) farming on large tract of land as a single operation, usually of sheep, cattle and/or cereals

broadscale relating to an activity that is carried out over a large area

BRS Bureau of Rural Sciences

BTR Bureau of Tourism Research

Burra Charter the Australia **ICOMOS** Charter for the Conservation of Places of Cultural Significance; a document prepared by the Australian Committee for the International Council for Monuments and Sites (Australia ICOMOS) to guide conservation philosophy and practice for cultural heritage places in Australia

bycatch species taken incidentally in a fishery where other species are the target; often discarded

CAMBA China–Australia Migratory Bird Agreement

CAR comprehensive, adequate and representative principles

carbon sequestration the process of removal of carbon dioxide from the atmosphere and its storage, particularly in soils and plant biomass; forms a significant part of global strategies for combatting the threat of climate change

carcinogen any agent that incites development of a cancer or any other sort of malignancy

carrying capacity maximum stocking rate that an area of grazing land can support throughout the greatest period of stress each year

catchment the area within which rainfall contributes to runoff to a particular water body

CBD central business district

CBWC Condamine Balonne Water Committee Inc.

CCMA Condamine Catchment Management Association

CD Collection District, the smallest geographically defined area used by the Australian Bureau of Statistics for census data collection

CE critically endangered

CFC chlorofluorocarbon synthetic **greenhouse gas** that contains chlorine and fluorine. Greenhouse gases deplete **ozone** in the stratosphere.

CHIEF Cultural Heritage and Information on the Environment and Forests Database

chlorophyll *a* plant pigment (used as a measure of algal concentrations in water)

CITES Convention on International Trade in Endangered Species

CKD cement kiln dust

cleaner production a holistic approach to reducing source inputs and waste outputs in the production process

climate the average weather conditions of a place or region throughout the seasons

climate change recent trends that are believed to result from human interference with the natural radiative properties of the atmosphere, due to increased greenhouse gas emissions

climate forcing an imposed, natural, or human-induced perturbation of the Earth's energy balance with space. Examples of natural climate forcing include volcanic eruptions (that produce negative forcing and hence a temporary reduction in global temperatures) and changes in the Sun's activity as solar variability (can result in either negative or positive forcing). Examples of human-induced forcing include aerosol pollution (smoke), land use change and increased concentrations of greenhouse gases.

climate projection a projection of the response of the climate system to emission of greenhouse gases often based upon simulations by climate models, using scenarios based on assumptions, concerning for example future socioeconomic and technological developments

climate variability the natural year-to-year and season-to-season variation of the climate system

closed forest forest in which the tree crowns cover 81–100% of the land area when viewed from above *see* **forest**

CLR Contaminated Land Register

CMP conservation management plan

CNG compressed natural gas

CO carbon monoxide a poisonous, colourless gas produced by incomplete combustion of petrol and diesel fuels

CO_2 carbon dioxide an odourless, colourless gas produced during respiration, decomposition of organic material and combustion

$CO_2{}^{e}$ CO_2 equivalent the amount of carbon dioxide that would cause the same amount of global warming as the **greenhouse gas** under discussion

COAG Council of Australian Governments

Coastal Act *Coastal Protection and Management Act 1995*

code of practice a text that states ways of achieving compliance with the general environmental duty for any activity that causes, or is likely to cause, environmental harm

co-generation the production of two forms of useful power, usually electricity and heat, from a single fuel source in a single process

collembola an order of wingless hexapods, commonly known as springtails, most of which feed on fungi and bacteria found in rotting organic material, especially in leaf litter

colloidal having the characteristics of a mixture with properties between those of a solution and those of a fine suspension

combustion the burning of gas, liquid or solid in which the fuel is oxidised, evolving heat and often light. Incomplete combustion of fuels such as wood and petrol produces pollutants such as carbon monoxide.

commencement the date on which provisions in legislation become law. It is not necessarily the date when the Act is passed in Parliament or when it receives the Governor's assent.

COMPASS Combining Profitability and Sustainability in Sugar

concurrence agency a body empowered to make decisions about, and set conditions for, applications under the **IP Act**

contaminant an undesirable or harmful impurity

COTS crown-of-thorns starfish

CPAC Coastal Protection Advisory Council

CPUE catch per unit of effort; the quantity by weight of fish taken by a fishing operation each day

crash grazing a practice whereby stock at very high densities rapidly graze and remove pasture within a paddock within a few days

CRC Cooperative Research Centre

CRCWMPC Cooperative Research Centre for Waste Management and Pollution Control

criteria pollutants air pollutants traditionally regarded as important in urban air—sulfur dioxide, carbon monoxide, nitrogen dioxide, ozone, particulate matter and lead (particulate and vapours)

Crustacea a phylum of chiefly aquatic arthropods, such as lobsters, prawns, barnacles etc., commonly having the body covered with a hard exoskeleton or carapace

cryosphere those portions of the Earth's surface where water is in a solid form, including sea ice, snow cover, glaciers and ice sheets

cryptogamic crust surface layer over unvegetated areas composed of mosses, lichens, algae and bacteria which protects soil from erosion, absorbs moisture, provides nutrients for plant growth and provides germination sites for seeds

CS Energy Callide Swanbank Energy

CSIRO Commonwealth Scientific and Industrial Research Organisation

CSR Colonial Sugar Refinery

cultural landscapes areas or features within Queensland that have been or are being used, altered or affected in some way by humans; and are of significance to humans for any anthropological, cultural, historic, prehistoric or societal reason

Cultural Record Act *Cultural Record (Landscapes Queensland and Queensland Estate) Act 1987*

cultural tourism travel oriented toward culturally significant destinations; might be broadly motivated by the desire to experience cultural diversity or to immerse oneself in the culture of a region

cyanobacteria microscopic, photosynthetic aquatic organisms; commonly referred to as **blue-green algae**

DATSIP Department of Aboriginal and Torres Strait Islander Policy

DEH Department of Environment and Heritage (Qld)

delegation in this report, a power of the chief executive of the EPA to transfer/share responsibility for administering the EP Act *see also* **devolution**

DES Department of Emergency Services

DEST Department of the Environment, Sport and Territories (Commonwealth)

development approval a development approval under the IP Act

devolution in this report, a power of the chief executive of the **EPA** to transfer responsibility for administering the **EP Act** *see also* **delegation**

dieldrin a persistent cyclodiene organochlorine insecticide with contact and stomach action on target insects and a tendency to bioaccumulate in the environment and fatty tissue of animals. Sale and use of the product have been effectively banned in Australia since 1991.

Diesel Vehicles NEPM National Environment Protection (Diesel Vehicles Emissions) Measure (2001)

diffuse source (pollution) from a broad area or many small sources, such as runoff from fields or urban areas *see* **point source**

dioxins chemical compounds largely formed as waste products or by-products in the manufacture of other chemicals. Some are hazardous to humans at relatively low levels.

displaced refers to species that are not native to an area but originate elsewhere in Australia *see* **translocation**

diuron a herbicide used to control both broad-leaf and grass weeds, absorbed principally through plant roots. It persists in soils for 4–8 months, depending on soil type and humidity.

diversion in water issues refers to the physical redirection of water from a water body producing an alteration of its natural flow regime. Diversion activities include the construction of dams, barrages and weirs, and water abstraction and harvesting for water supply, irrigation and power generation.

DLA Designated Landscape Area under the *Cultural Record (Landscapes Queensland and Queensland Estate) Act 1987*

DME Department of Mines and Energy (Qld)

DNR Department of Natural Resources (Qld)

DNRM Department of Natural Resources and Mines (Qld)

DoE Department of Environment (Qld)

domestic animals animals directly managed by humans *see also* **feral animals**

DPI Department of Primary Industries (Qld)

DPW Department of Public Works (Qld)

drawdown the difference between the level of water in a bore and the standing water level outside the bore

drown-out flows the flow rate in a river required to submerge an artificial barrier such as a weir

dryland land (usually cropping or grazing land) that is not irrigated

DSD Department of State Development

DSE dry sheep equivalent (usually 50 kg)

DSI Dust Storm Index

DU Dobson Units

E endangered

ECe electrical conductivity

ecologically sustainable development development that improves the total quality of life, both now and in the future, in a way that maintains the ecological processes on which life depends

ecosystem a dynamic complex of plant, animal and micro-organism communities and their non-living environment interacting as a functional unit

ecosystem services the role played by organisms in creating a healthy environment for human beings, for example, in production of oxygen, soil formation, maintenance of water quality

ecotone the boundary or transition area between two or more habitats or communities

EEA European Environment Agency

effluent a discharge or emission of a waste product

EHMP Ecosystem Health Monitoring Program

EIA environmental impact assessment

EIS *see* **environmental impact statement**

El Niño a warm water current that periodically flows southwards along the coast of Ecuador and Peru in South America, replacing the usually cold northwards-flowing current. The name refers to the Christ child as the current usually appears around Christmas. The opposite phase is called **La Niña**.

emission gaseous or liquid discharge given out by a source

EMP *see* **environmental management program**

EMR Environmental Management Register

EMS environmental management system

endangered species a plant or animal that is in danger of becoming **extinct** or whose survival in the wild is unlikely if threatening processes continue

endemic native to a particular area and found (naturally) nowhere else

endosulfan an organochlorine insecticide with contact action. Unlike most members of this group, it largely disappears from soil in 3–6 months and does not remain in the bodies of animals or humans. It is quite toxic to fish and other aquatic organisms.

enhanced greenhouse effect *see* **greenhouse effect**

ENSO El Niño-Southern Oscillation a regional climate pattern in the Pacific characterised by fluctuations of surface pressure and mean sea levels and sea temperatures between the east and west Pacific. These fluctuations take place over time scales of 3–7 years and cause changes in average rainfall, wind speed and temperature in Pacific and South American countries, but also have an influence on weather patterns outside this region as far as Africa. ENSO causes drought conditions over eastern Australia. see **El Niño** and **La Niña**

environmental audit an audit requested by an administering authority where it is reasonably satisfied that a person is not complying with licence conditions, a development condition of a development approval, or an environmental protection policy or management program

environmental authority a licence or approval

environmental evaluation an environmental audit or investigation

environmental flows minimum flows of water (by volume and by season) necessary to maintain all aquatic biota and ecosystem processes

environmental impact statement a report containing both the beneficial and adverse (environmental, social and economic) impacts potentially arising from a project; measures to minimise adverse impacts; feasible alternative ways of carrying out the project; a proposed environmental management plan; and any other information needed by administering authorities to make a regulatory decision

environmental investigation an investigation requested by an administering authority where it is satisfied on reasonable grounds that an event, activity or proposed activity is causing or is likely to cause serious or material environmental harm

environmental management plan a document that proposes conditions and mechanisms to manage the potential environmental impact of a project

environmental management program a specific program that, when approved, achieves compliance with the EP Act for specified matters by reducing environmental harm, or detailing the transition to an environmental standard

environmental protection policy subordinate legislation under the EP Act that may be made about the environment or anything that affects or may affect the environment. An EPP may make provision about anything about which a regulation may be made under the EP Act, and may prescribe offences for contraventions of the policy and fix a maximum penalty of a fine.

environmental value a quality or physical characteristic of the environment that is conducive to ecological health or public amenity or safety, or another quality of the environment identified and declared to be an environmental value under an environmental protection policy or regulation

environmentally relevant activity an activity which when carried out will or may release into the environment contaminants that will or may cause environmental harm. ERAs are prescribed in Schedule 1 of the *Environmental Protection Regulation 1998*; they can be of level 1 or level 2, depending on their risk to the environment.

EO environmental order

EP Act *Environmental Protection Act 1994*

EP Regulation *Environmental Protection Regulation 1998*

EPA Environmental Protection Agency (Qld)

EPBC Act *Environment Protection and Biodiversity Conservation Act 1999* (Cwlth)

EPHC Environment Protection and Heritage Council

epibenthic living above the bottom of the sea-floor

EPO *see* **environmental protection order**

EPP *see* **environmental protection policy**

ERA *see* **environmentally relevant activity**

ERDC Energy Research and Development Corporation (Commonwealth Government)

erodibility the susceptibility of a soil to the detachment and transportation of soil particles by erosive agents

erosivity the potential ability to cause erosion. The term is commonly applied to rainfall.

ES exotic species

ESAA Electricity Supply Association of Australia

ESD *see* **ecologically sustainable development**

estuary area of a coastal river mouth, characterised by tidal effects and mixing of fresh with sea water

ethno-biological knowledge the knowledge of biological processes specific to a particular group of people

ethnolinguistics the study of how language determines and reflects people's world views

EUM model extended urban metabolism model

eutrophic over-enriched by nutrients, primarily nitrogen and phosphorus, stimulating excessive growth of organisms and depletion of oxygen concentration

exceedence an occasion when a goal, guideline or standard is exceeded

exotic species a non-native species that has been introduced to a region

extinct species *see* **presumed extinct species**

extraction withdrawal of water for agriculture, mining, industry or urban uses

faecal coliforms indicator organisms used to test for the presence of enteric bacteria

fallow (of land) not being cropped

family a group of species of common descent higher than the genus and lower than the order

FATSIL Federation of Aboriginal and Torres Strait Islander Languages

fauna all of the animals found in an area *see also* **flora**

FCCC *see* **UNFCCC**

feral animals animals that have reverted to a wild state from domestication *see also* **domestic animals**

ferrosols well-drained red or yellow-brown clay loam and clay soils. Occur mainly around Kingaroy and Atherton where they are used for intensive agriculture such as maize, peanuts, potatoes and dairying.

FHA fish habitat area

floodplain a nearly flat plain along the course of a stream naturally subject to flooding at high water

flora all of the plants found in an area *see also* **fauna**

FNQ far north Queensland

forest an area that is dominated by trees usually having a single stem and a mature stand height of over two metres and in which the tree crowns cover at least 20% of the land area when viewed from above *see* **woodland, open forest, closed forest**

fossil fuel any hydrocarbon deposit that can be burned for heat or power, such as coal, oil and natural gas

fragmentation when used in the context of vegetation or habitat, refers to division and isolation of vegetation/habitat by vegetation clearing, isolating species and limiting genetic flow

freehold land owned privately *see also* **leasehold**

freeholding lease a form of land tenure; a lease with option to convert to freehold

fuel cell device that converts one form of energy into another, for example, chemical energy into electrical energy

fugitive emissions pollutant releases not confined to a stack, duct or vent

GAB Great Artesian Basin, the largest system of groundwater aquifers in Australia

GABCC Great Artesian Basin Consultative Council

GABSI Great Artesian Basin Sustainability Initiative

GAMS Gladstone Airshed Modelling System

GBRMP(A) Great Barrier Reef Marine Park (Authority)

GBRWHA Great Barrier Reef World Heritage Area

GCCC Gold Coast City Council

gene the basic unit of heredity

general environmental duty the responsibility of a person not to carry out any activity that causes, or is likely to cause, environmental harm unless that person takes all reasonable and practicable measures to prevent or minimise the harm

genus (plural **genera**) a group of closely related species

GHG *see* **greenhouse gas**

gibber (terrain covered with) the smoothed and rounded weatherworn stones of the arid Australian centre

GIS geographic information system a computerised system for the capture, storage, analysis and display of geographically referenced information

global warming a rise in world temperature expected from increased concentrations of **greenhouse gases**

GMU groundwater management unit

GQAL good quality agricultural land

green energy energy generated from renewable resources

green waste garden, food and wood wastes that are compostable and/or can be shredded and used for mulching

greenhouse effect the natural warming of the Earth's atmosphere as a consequence of the concentration of trace gases that retard the escape of heat radiation. The 'enhanced greenhouse effect' is the expected increase in the Earth's temperature as a result of the increase in **greenhouse gas** concentrations. The term 'greenhouse effect' is popularly used for the 'enhanced greenhouse effect'.

greenhouse gas gas occurring naturally or produced or by human activity which enhances the natural 'greenhouse effect'. Greenhouse gases include carbon dioxide, methane, halocarbons, nitrogen oxides, **ozone** and water vapour.

greywater wastewater usable for a limited range of purposes such as garden irrigation or industrial cooling

ground truth to verify on-site data deduced from a model, satellite picture or aerial photograph

groundwater water occurring below the ground surface *see* **aquifer**

growout a stage in aquaculture production where individual fish are grown to marketable size

GST Goods and Services Tax

GVP gross value production

habitat the place where an animal or a plant normally lives and reproduces

halocarbons generic term for bromo-, chloro- and fluorocarbons, synthetic **greenhouse gases**, used in various technologies

halons halons include bromofluorocarbons and bromochlorofluoro carbons, which are very stable chemicals that are involved in ozone depletion in a similar manner to CFCs.

HAPs hazardous air pollutants

hardwood in this report, refers to native timbers such as eucalypts, wattles and most rainforest species *see also* **softwood**

haul-out a machine/trailer that runs alongside a cane harvester and receives the cut cane from the field. Once full, the haul-out carts the cane to the nearest rail truck/depot.

hazard-reduction burning deliberate burning of forests and grasslands in calm or near-calm conditions to reduce the level of flammable material on the ground to limit the potential for destructive wildfires under other conditions

haze the presence of very small airborne particles in concentrations large enough to impede vision

HBFCs hydrobromofluorocarbons

HCFCs hydrochlorofluorocarbons chemicals used as interim replacements for CFCs, usually as refrigerants, with lower ozone-depleting potential than CFC

HDPE high-density polyethylene

heritage places, objects and indigenous languages that have aesthetic, architectural, historical, scientific, technological or social significance or other special value for future generations as well as for the community today; the value of that heritage might or might not be fully recognised

Heritage Act *Queensland Heritage Act 1992*

HFCs hydrofluorocarbons

HiVol high-volume sampler provides 24-hour samples of particle levels (**TSP** and **PM_{10}**) on a 1-day-in-6 cycle. Lead concentrations are measured using high-volume samplers.

hydrocarbon an organic molecule containing hydrogen and carbon, the major components of petroleum

hydrological dealing with water on the land or under the Earth's crust, its properties, laws and geographic distribution

IAWM Integrated Area-Wide Management Project

IBRA Interim Biogeographical Regionalisation for Australia

ICOMOS International Council for Monuments and Sites

ICP infrastructure charges plan

IDAS Integrated Development Assessment System

IEMS submission an application for an Integrated Environmental Management System under Queensland legislation for managing the environmental impacts of carrying out an environmentally Relevant Activity

IGAE Intergovernmental Agreement on the Environment

ILO Indigenous Language Officer

ILUA Indigenous Land Use Agreement under the *Native Title Act 1993*

IMCRA Interim Marine and Coastal Regionalisation for Australia

impervious surface roofed, paved or compacted areas of the ground that prevent water runoff from penetrating underlying soil

in situ conservation conserving a species or an object within its natural or original environment *see also* **off-site conservation**

indicator species a species that is used to assess the health of an entire ecosystem

Indigenous (people) in this report, Indigenous Australians means Aboriginal people and Torres Strait Islanders

infrared radiation radiation invisible to the human eye, which has less energy and longer wavelengths than visible light

integrated environmental management system *see* **IEMS submission**

intergenerational equity the principle that the present generation should pass on to future generations an environment that is not impoverished and degraded and that will not reduce the quality of life for future generations

Interim Waste Regulation *Environmental Protection (Interim Waste) Regulation 1996*

intertidal between the levels of low and high tide

inversion (temperature) when air temperature increases rather than decreases with height

invertebrates group of animals without a backbone composed of vertebrae, that is, segments or bone comprising a column through which the spinal cord passes, not including protozoans *see also* **vertebrate**

IP Act *Integrated Planning Act 1997*

IPCC Intergovernmental Panel on Climate Change

IRPF integrated regional planning framework

IRTP Integrated Regional Transport Plan

IUCN International Union for Conservation of Nature and Natural Resources

JAMBA Japan–Australia Migratory Bird Agreement

JOL John Oxley Library

kandosols red, yellow and grey soils with 'earthy' porous loamy subsoils which have low fertility levels and poor water-holding capacity. Kandosols are found in mulga areas around Charleville and support cattle and sheep grazing on native pastures.

keeping place a community museum housing Aboriginal or Torres Strait Islander social history collections

La Niña the opposite of an **El Niño** phase; occurs when the **SOI** is strongly positive. La Niña phases are associated with higher than usual rainfall in eastern and northern Australia.

LADM Lagrangian Atmospheric Dispersion Model

lake area of open water, generally over one metre deep, with little or no persistent emergent vegetation

LANDSAT the land and earth resources satellite system

leaching act of percolating through, as water through a porous material

leasehold land owned by government but leased to a specific person or organisation for a specific purpose *see also* **freehold**

LGA local government area

LGAQ Local Government Association of Queensland

lignotuber a taproot that has fused with the stem and may become woody. Lignotubers often occur in seasonally dry or fire-prone habitats and assist in recovery from dormancy or fire.

lithosphere the solid outer portion of the Earth's crust coupled to the rigid upper mantle

littoral relating to a shore, usually a sea shore

LMS Museum of Lands, Mapping and Surveying

LPG liquid petroleum gas

LPU local pasture unit a localised area of distinctive pasture communities. There are 19 pasture communities and 46 LPUs in Queensland as defined by Tothill and Gillies (1992).

LR lower risk

LWMP land and water management plan

LWRRDC Land and Water Resources Research and Development Corporation

macro-invertebrates animals without backbones, visible to the naked eye

macrophytes plants visible to the naked eye

macropods marsupials belonging to the Family Macropodidae, which includes kangaroos, wallabies, tree-kangaroos and pademelons

MAF mean annual flow

MAQ Museums Australia (Queensland)

mesoscale all scales ranging from 20 km to 200 km above the Earth

methane a major greenhouse gas produced by rice paddies, some fossil fuel combustion, and enteric fermentation in ruminant animals *see* **greenhouse gas**

metolachlor a herbicide used for the control of annual and broad-leaf grasses, absorbed mainly by hypocotyls and shoots. It has a relatively short half-life in soil of approximately 20 days.

MICC Mount Isa City Council

MIM Mount Isa Mines

modelling mathematical simulation of wind flows, air pollutant dispersion and chemical reactions requiring sophisticated and powerful computers

Montreal Process the informal agreement by the Montreal Process Group of countries (currently 12 including Australia) to work towards the implementation of a comprehensive set of criteria and indicators for forest conservation and sustainable management

MRHI Monitoring River Health Initiative

mS/cm (inland waters)

multiparameter monitoring monitoring where more than one aspect of the environment is measured simultaneously at a recording station to give comparative results of different parameters, for example, air quality and weather conditions

multiple use managing an area (national or marine parks or forests) to achieve multiple goals or multiple outputs, usually conservation with recreation and/or commercial activities

MVEC Motor Vehicle Environment Committee

na or **n.a.** (in tables) where not otherwise specified, means not applicable or not available

NAP national action plan

NAPSWQ National Action Plan for Salinity and Water Quality

NASA National Aeronautics and Space Administration (United States of America)

National Estate Grants Program a Commonwealth Government funding program to assist the identification, conservation and presentation of heritage places across Australia that are recognised by the **Register of the National Estate** or by State Heritage Registers

National Greenhouse Strategy the strategy developed by Commonwealth, State and Territory governments for managing climate change caused by increased greenhouse gas concentrations

native title recognition of rights held by Aboriginal or Torres Strait Islander people according to their laws and customs involving location of land, the rights held, and identification of the holder of the rights

naturalised species a species introduced to an area outside its natural range and that has established self-sustaining populations

NEGP National Estate Grants Program

NEPC National Environment Protection Council

NEPM National Environment Protection Measure

NGS National Greenhouse Strategy

NHMRC National Health and Medical Research Council

NHT Natural Heritage Trust. A Commonwealth Government fund, sourced from the partial sale of Telstra, the national communications company

NHT2 the second phase of the Natural Heritage Trust

NLP National Landcare Program

NLWRA National Land and Water Resources Audit

NOAA National Oceanographic Atmospheric Administration

Noise EPP *Environmental Protection (Noise) Policy 1997*

non-point source *see* **diffuse source**

non-renewable resources natural resources that are in fixed supply, but whose lifespan can be extended through more efficient or reduced use, reuse or recycling (e.g. minerals, oil, coal)

NORSROC Northern Sub-regional Organisation of Councils (Caboolture, Caloundra, Kilcoy, Maroochy, Noosa, Pine Rivers, Redcliffe)

NO nitric oxide

NO_2 nitrogen dioxide

NO_x nitrogen oxides. Nitrogen monoxide (NO) and nitrogen dioxide (NO_2) are the most common.

NPI National Pollutant Inventory

NPI NEPM National Environment Protection (National Pollutant Inventory) Measure (as varied June 2000)

NQLC North Queensland Land Council

NS native species

NSW New South Wales

NTU nephelometric turbidity units

ODP ozone-depletion potential

ODS ozone-depleting substance

OECD Organisation for Economic Cooperation and Development

off-site conservation conservation of a species or an object outside its natural or original environment *see also* **in-situ conservation**

old-growth forest ecologically mature **forest** where the effects of disturbances are now negligible

open forest forest in which the tree crowns cover 51–80% of the land area when viewed from above *see* **forest**

organochlorine a hydrocarbon compound containing chlorine. Many pesticides and industrial chemicals are organochlorines.

orographic pertaining to rain or clouds caused by the effects of mountains on airstreams that cross them

OSE Office of Sustainable Energy, Department of Mines and Energy (Qld)

otter trawling trawling using a particular type of equipment used to capture prawns and scallops

overturning ocean circulation ocean currents that control how much heat and carbon are stored in the ocean, also providing nutrients that fuel Southern Ocean and Antarctic ecosystems, and supplying oxygen to the deep ocean

ozone a gas made of three oxygen atoms which occurs naturally in the atmosphere, where it protects the Earth from solar **ultraviolet radiation**

ozone depletion the process whereby the natural equilibrium between chemical reactions forming and destroying stratospheric ozone is disturbed by the release of manufactured chemicals which reduce the amount of ozone in the atmosphere, leading to increased UV radiation on Earth

ozone hole loss in concentration of **ozone** in some part of the ozone layer

ozone layer a region in the stratosphere (12–50 km above the Earth) where there is a small, but significant, amount of ozone that protects the Earth by absorbing some of the UV radiation emitted from the sun

PAH polycyclic aromatic hydrocarbon

pan evaporation the water loss per unit time from a standard container; an indirect method of estimating the transfer of water vapour from land and vegetation to the atmosphere

Pb lead

PCB polychlorinated biphenyl

PCQ Ports Corporation of Queensland

PET polyethylene terephthalate

petrochemicals chemicals made from feedstocks derived from petroleum or natural gas

PFC perfluorocarbon

pH a measure of acidity or alkalinity, expressed on a logarithmic scale from 1 to 14. 1 is most acid, 7 is neutral and 14 is most alkaline.

photochemical reaction a chemical reaction that takes place in sunlight

photochemical smog air pollution caused by chemical reactions among various substances (predominantly NO_x and hydrocarbons) and pollutants in the atmosphere in the presence of sunlight. Ozone is a major component of photochemical smog and ozone concentrations are used as an indicator of photochemical smog.

phytoplankton microscopic plants and **cyanobacteria** that live free-floating in an aquatic environment

PIN penalty infringement notice

$PM_{2.5}$ particles with an equivalent aerodynamic diameter of 2.5 micrometres

PM_{10} particles with an equivalent aerodynamic diameter of 10 micrometres

point source source of pollution that can be pinpointed such as a drain or chimneystack *see also* **diffuse source**

point-source pollution source of pollution that can be pinpointed, such as a stack releasing emissions at an industrial facility

precautionary principle a principle that states that when there are threats of serious irreversible damage, scientific uncertainty shall not be used to postpone cost effective measures to prevent environmental degradation

prescribed burning *see* **hazard-reduction burning**

presumed extinct species a plant or animal that has not been seen in the wild for a period critical to its life cycle despite thorough searching

primary pollutants pollutants which are emitted directly into the atmosphere and which may react with substances or sunlight to produce other pollutants

primary treatment removal of gross and settleable solids and stabilisation of the organic component of these solids. Primary treatment processes include screening, comminution, maceration, grit and detritus removal, pre-aeration, grease removal, primary sedimentation and sludge digestion, including the addition of chemicals. *see also* **secondary treatment** and **tertiary treatment**

pristine aquatic ecosystem aquatic ecosystem that has not been or is not subject to human interference through releases (direct or indirect) into a water forming part of the ecosystem or activities in the water's catchment area

protected area an area of land and/or sea especially dedicated to the protection and maintenance of biological diversity, and of natural and associated cultural resources, and managed through legal or other effective means

QAG Queensland Art Gallery

QCB Queensland Coal Board

QCCHIP Queensland Community Cultural Heritage Incentive Program

QCPTA Queensland Cleaner Production Taskforce Association

QDCILGP Queensland Department of Communication, Information, Local Government and Planning

QDEH Queensland Department of Environment and Heritage

QDHLGP Queensland Department of Housing, Local Government and Planning

QDHLGP Queensland Department of Housing, Local Government and Planning

QDLGP Queensland Department of Local Government and Planning

QFMA Queensland Fisheries Management Authority

QFRS Queensland Fire and Rescue Service

QFS Queensland Fisheries Service

Qgraze a pasture monitoring program in Queensland rangelands

QHGP Queensland Heritage Grants Program

QHR Queensland Heritage Register

QHTN Queensland Heritage Trails Network

Qld Queensland

QLUMP Queensland Land Use Mapping Program

QM Queensland Museum

QMS quality management system

QPWS Queensland Parks and Wildlife Service

QR Queensland Rail

QRAC Queensland Recycling Advisory Council

QSA Queensland State Archives

QSEIF Queensland Sustainable Energy Innovation Fund

QT Queensland Transport (a Queensland Government department)

QTSC Queensland Transmission and Supply Corporation

QTTC Queensland Tourism and Travel Corporation

Ramsar Convention on Wetlands of International Importance Especially as Waterfowl Habitat, entered into force in 1975. The Convention, including the List of Wetlands of International Importance established under it, is administered by the **IUCN**.

rangelands land used for grazing livestock on native pastures where rainfall is too low for more intensive agriculture

rare species a plant or animal whose population is represented by a relatively large population in a restricted range or a smaller population thinly spread over a wider range

RCG regional consultative group

reach environs those lands immediately adjacent to the riparian zone and including the floodplain and valley flat

recharge downward flow of water through soil and underlying rock to an aquifer

recirculation recycling of pollutants over an area or within an airshed in response to reversal winds

recovery plan a document stating the research and management actions necessary to stop the decline, support the recovery and enhance the chance of long-term survival in the wild of a stated species or community of protected wildlife

recruitment the general addition of fish, plants or animals to an existing stock or population

refugia areas that have been protected from environmental changes such as increasing aridity or fire

Register of the National Estate a national heritage register that covers significant natural, historic and Aboriginal and Torres Strait Islander places across Australia

regulated watercourse watercourse whose flow is regulated by dams, weirs and other works

remediate take action to restore or rehabilitate contaminated land, or to prevent or minimise environmental harm arising from that contamination

remnant vegetation vegetation that has been mapped by the Queensland Herbarium. It includes vegetation that has been subject to minimal disturbance and regrowth vegetation that meets a prescribed set of criteria.

renewable resource natural resource that is naturally replenished (e.g. energy from the wind)

RFA Regional Forest Agreement

RFGM Regional Framework for Growth Management—the primary regional planning strategy for South East Queensland

RFISH Recreational Fishing Information System

RGAQ Regional Galleries Association of Queensland

riparian relating to the bank of a river or other water body

RNE Register of the National Estate

ROP resource operation plan

RPAC regional planning advisory committee

runoff the portion of rain not immediately absorbed into the soil which becomes a surface flow

RWUEI Rural Water Use Efficiency Initiative

saltflat wide expanse of flat country in which the soil is very salty

saltmarsh an intertidal plant community complex dominated by herbs and low shrubs

saltpan a basin flooded by salt deposits; the remains of evaporated salt water

savanna a vegetation type with scattered trees over a grassland, usually found in subtropical areas

SCMQW Strategy for the Conservation and Management of Queensland's Wetlands

SD Statistical Division, an Australian Bureau of Statistics area for data collection

seagrass flowering plant adapted to living wholly submerged in seawater

secondary pollutants pollutants formed by chemical reaction in the atmosphere (e.g. photochemical smog results from the mixing of NO_x and hydrocarbons in the presence of sunlight)

secondary treatment conversion and stabilisation of non-settleable organic matter into settleable organic matter. Secondary treatment can include carbon removal, carbon and nitrogen removal, or carbon, nitrogen and phosphorus removal. Secondary treatment processes include activated sludge, biological treatment using solid media, sludge digestion, lagoons and wetlands.

sediment matter that settles to the bottom of a water body

sedimentation deposition or accumulation of sediment

SEIFAs Socio-Economic Indexes for Areas

SEQ 2001 a project, initiated in 1991 by the Queensland Government, to plan for projected population growth in south-east Queensland to the year 2001. Term also refers to an area.

SEQ IRTP South East Queensland Integrated Regional Transport Plan

SEQRAQS South East Queensland Regional Air Quality Strategy

SEQRFA Southeast East Queensland Regional Forest Agreement

serious environmental harm environmental harm (other than environmental nuisance) that:

- causes actual or potential harm to environmental values that is irreversible, of a high impact or widespread; or
- causes actual or potential harm to environmental values of an area of high conservation value or special significance; or
- causes actual or potential loss or damage to property of an amount of, or amounts totalling, more than $50 000; or
- results in costs of more than $50 000 being incurred in taking appropriate action to prevent or minimise the harm, and to rehabilitate or restore the environment to its condition before the harm.

sewage waste matter discharged into a **sewerage** system

sewerage a system for collecting, treating and disposing of wastewater and refuse, usually with underground pipes and fittings

sinks places or processes that remove or absorb materials from a system

SLA Statistical Local Area, an Australian Bureau of Statistics defined area for data collection

SLATS Statewide Landcover and Trees Study (Department of Natural Resources and Mines)

smog *see* **photochemical smog**

SMP site management plan

sodosols texture contrast soils with impermeable subsoils due to the accumulation of sodium. Sodosols occur in large areas of inland Queensland and mainly support grazing, timber and honey production. They are highly prone to erosion and dryland salinity.

SoE State of the Environment

softwood timbers from pines and cypresses, generally sourced from plantation forests

SOI Southern Oscillation Index

SouthROC Southern Region Organisation of Councils (Beaudesert, Gold Coast, Logan, Redland)

sp. (singular) and **spp.** (plural) species, a group of similar organisms that can generally interbreed only amongst themselves to produce fertile offspring

SPER State Penalties Enforcement Registry

SPP state planning policy

stakeholder someone who is affected by or involved in the issue under discussion

standard criteria under the EP Act, criteria for an environmental authority, EMP, EPO or removal permit, including environmental, economic and social considerations. They are listed in Schedule 4 of the Act.

storages impoundments and ponds designed as water supplies for irrigation, urban water supply, electricity generation and for flood mitigation

STP sewage treatment plant

stratification layering of a body of water due to physical differences in upper and lower layers. It is common in deep, still water bodies due to the density gradient between cooler deep water and warmer upper layers that can develop in spring and summer months.

stratosphere the region of the atmosphere roughly 15 to 20 km above the Earth's surface *see also* **troposphere**

sub-artesian aquifer water-bearing formation that, when it is tapped by a bore, shaft, well, gallery, spear or excavation, is subjected to hydrostatic pressure that does not allow the standing water level (or potentiometric level) to rise above the ground surface

subordinate legislation legislation that is secondary to and dependent on an Act. For the EP Act, subordinate legislation includes EPPs, regulations and notices of codes of practice.

subregions areas that have been delineated by the EPA within bioregions on the basis of major geomorphic and geological patterns

suspended solids suspended particles in a water body *see* **turbidity**

SWEEP Strategic Weed Eradication and Education Program

tailings leftover material after extraction of a mineral

tapered element oscillating microbalance (TEOM) an instrument that samples the air continuously and collects the particles on a filter attached to an oscillating microbalance. TEOM instruments are used to measure particles including PM_{10} and $PM_{2.5}$.

taxon (plural **taxa**) the named classification unit to which individuals, or sets of species are assigned such as species, genus, family, phylum etc.

TBT tributyltin

temperature inversion a layer in the atmosphere in which temperature increases with altitude. The principal characteristic of an inversion layer is its marked static stability, so that very little turbulent exchange can occur within it.

tertiary treatment removal of fine non-settleable matter and additional biological treatment over and above **secondary treatment**

threatened species a plant or animal that is **endangered**, **vulnerable** or **presumed extinct**

tillage mechanical disturbance of the soil such as ploughing

TOC total organic carbon

toxicity effect of any substance that harms living organisms, described as acute (short-term) or chronic (long-term)

TQ Tourism Queensland

translocation the movement of native organisms from their native range to another region

transpiration loss of water through the leaves of plants to the atmosphere

troposphere the lower layer of the atmosphere extending to roughly 15 km above the Earth's surface. This is the layer in which weather processes occur. *see also* **stratosphere**

TSP total suspended particles. Includes all particles from the smallest up to those 50µm in diameter. Particles less than 10 µm (PM_{10}) and particles less than 2.5 µm ($PM_{2.5}$) are of greatest concern for human health because they are inhaled deeply into the lungs.

turbidity optical measure of light-absorbing materials in a water sample; surrogate measure of **suspended solids**

UA unincorporated area area of Queensland not incorporated into a groundwater management unit

UNEP United Nations Environment Programme

UNEP-CBD United Nations Environment Programme—Convention on Biological Diversity

UNEP-WCMC United Nations Environment Programme—World Conservation Monitoring Centre

UNESCO United Nations Educational, Scientific and Cultural Organization

UNFCCC United Nations Framework Convention on Climate Change

USEPA United States Environmental Protection Agency

UV ultraviolet radiation electromagnetic radiation of higher frequencies and shorter wavelengths than visible light

V Vulnerable

vascular plants a grouping of plants that include the flowering plants and gymnosperms

vertebrate an animal with a backbone composed of vertebrae, that is, segments or bone comprising a column through which the spinal cord passes *see also* **invertebrate**

vertosols clay soils that swell when wet and shrink when dry, leaving open cracks on the surface. Vertosols are found in floodplain areas and generally have high fertility and water-holding capacity and are suited to intensive dryland agriculture, where rainfall permits, and irrigation.

VOC volatile organic compound an organic compound with a boiling point between 50°C and 260°C

Vpd vapour pressure deficit the difference between actual vapour pressure and the saturation vapour pressure

VPO Vegetation Protection Order

vulnerable species a plant or animal whose population is decreasing, has been seriously depleted or is at risk due to threatening processes

Walker Circulation an east-west air circulation confined to equatorial regions of the Pacific Ocean and driven principally by the oceanic temperature gradient

Waste EPP *Environmental Protection (Waste Management) Policy 2000*

Water EPP *Environmental Protection (Water) Policy 1997*

water harvesting pumping of water from streams into storages during periods of high flow

watertable the upper limit of the portion of ground saturated with water

weir obstruction in a stream or river to detain water and/or raise the water level for irrigation

WESROC Western Subregional Organisation of Councils (Boonah, Esk, Gatton, Ipswich, Laidley, Toowoomba)

wetland an area of permanent or periodic/intermittent inundation, whether natural or artificial, static or flowing, fresh, brackish or saline, including an area of marine water the depth of which at low tide does not exceed six metres

WHO World Health Organization

wilderness remote area that is substantially undisturbed by human activities

WildNet a computerised information system for Queensland's wildlife managed by the EPA

woodland forest in which the tree crowns cover 20–50% of the land area when viewed from above *see* **forest**

woody weeds shrubby plants, both native and exotic, that have infested pastures

World Heritage a term applied to sites of outstanding universal natural or cultural significance adopted as World Heritage under the World Heritage Convention (1972)

WRP water resource plan

WTMA Wet Tropics Management Authority

xylene an aromatic hydrocarbon emitted into the atmosphere through combustion of organic matter such as wood, coal, and petroleum products. Motor vehicle emissions are the predominant source of xylene in the urban air environment.

zooplankton microscopic marine animals that float in the water column

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