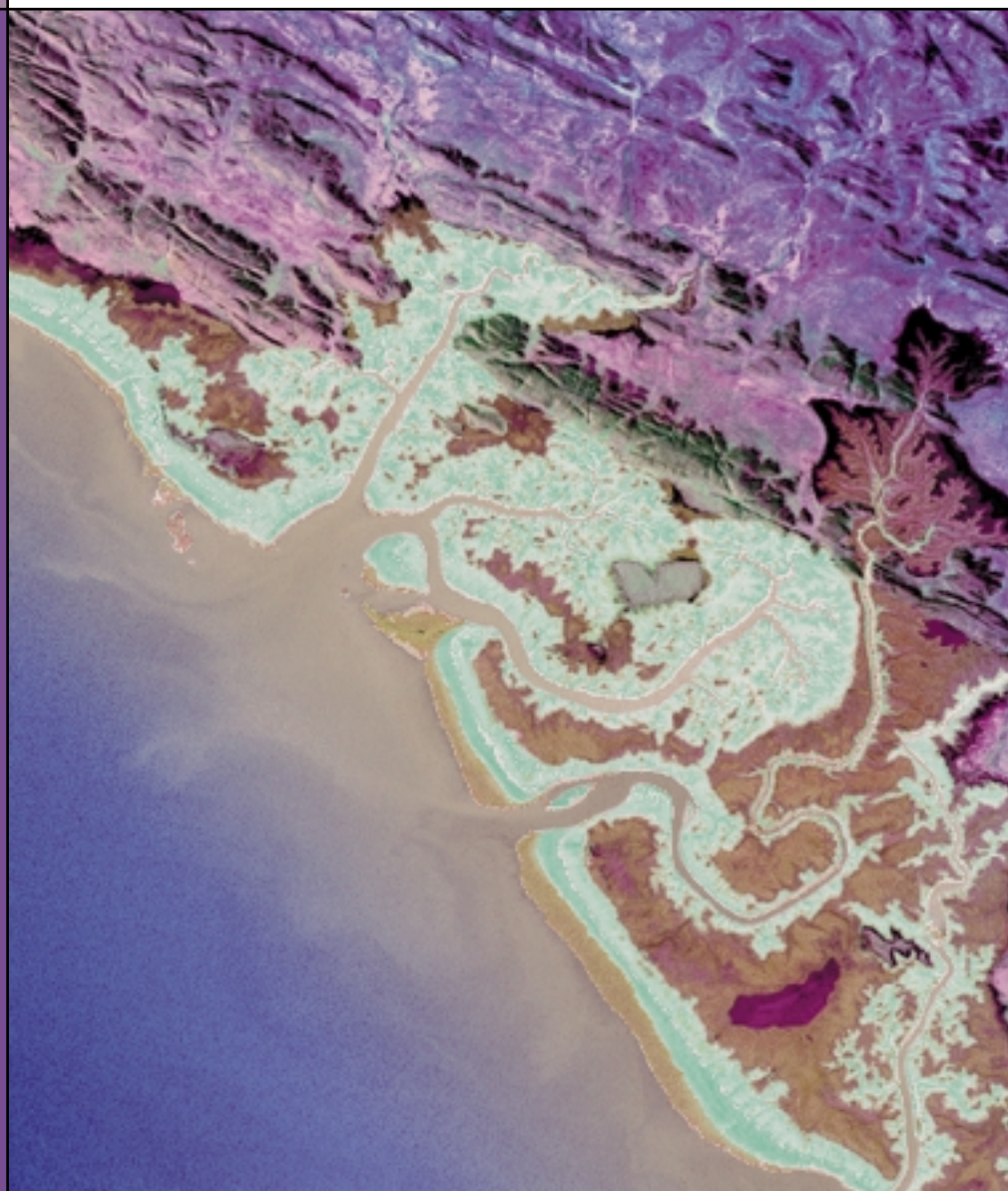
ANZECC

Core Environmental Indicators for Reporting on the State of the Environment

Australian and New Zealand
Environment and Conservation Council
State of the Environment Reporting Task Force

March 2000

AUSTRALIAN AND NEW ZEALAND
ENVIRONMENT AND CONSERVATION COUNCIL



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FOREWORD

Internationally, state of the environment (SoE) reporting has become a widely accepted process which aids environmental decision-making and enables assessment of progress towards ecological sustainability. In Australia, state of the environment reporting is now a legislative requirement at the Commonwealth level and in several State/Territory jurisdictions. In addition, SoE reports are now routinely produced by many local Governments. Since the production of Australia's first comprehensive and independent report, *Australia: State of the Environment 1996*, there has been much research and development regarding the use of environmental indicators for SoE reporting. A landmark outcome of this work was the series *Environmental Indicators for National State of the Environment Reporting* which covered each of the seven main themes currently used for national SoE reporting.

This report represents a further phase in the development of environmental indicators by introducing a set of 'core' indicators. The core set of indicators was chosen on the basis that they can be used to report on the state of the environment across jurisdictions within Australia. The set of indicators covers six of the SoE reporting themes: the atmosphere, biodiversity, the land, inland waters, estuaries and the sea (this theme is now referred to as coasts and oceans for the 2001 Australian SoE Report), and human settlements. Indicators for the seventh theme, natural and cultural heritage, will be developed through a separate process.

The identification and development of the core set of indicators has been carried out by the Australian and New Zealand Environment and Conservation Council (ANZECC) State of the Environment Reporting Task Force. A draft set of core indicators was published in the form of a discussion paper for public comment in July 1998 and over 100 public submissions were received. This final report is based on incorporation of many of the points made in the submissions after consideration and agreement by the Task Force. This report therefore identifies a set of core indicators that are scientifically valid and available for application in all jurisdictions choosing to adopt them.

This core set of environmental indicators was endorsed in December 1999 by ANZECC Ministers. ANZECC recognised that the core set will continue to evolve as the suitability and applicability of the indicators are demonstrated through use by the Australian community. Further core indicators can be added as understanding of the environment and methodologies for data collection and analysis continue to improve. In the next phase of this work, the ANZECC SoE Reporting Task Force will review the core set regarding methodologies and protocols for their application and interpretation. Together with the more specific indicators currently in use by the various States, Territories and Local Governments, these core indicators will help to build a truly national picture of trends in the Australian environment.

PARTICIPATING ORGANISATIONS

The organisations participating in the ANZECC State of the Environment Reporting Task Force are:

- Australian Bureau of Statistics
- Australian Capital Territory Department of Urban Services
- Australian Capital Territory Office of the Commissioner for the Environment
- Commonwealth Department of the Environment and Heritage
- Commonwealth Scientific and Industrial Research Organization
- New South Wales Environment Protection Authority
- New Zealand Ministry for the Environment
- Northern Territory Department of Lands, Planning and Environment
- Queensland Environment Protection Agency
- South Australian Department for Environment, Heritage and Aboriginal Affairs
- Tasmanian Resource Planning and Development Commission
- Victorian Environment Protection Authority
- Western Australia Department of Environmental Protection

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PART ONE: BACKGROUND

Aim

This report presents a set of indicators, referred to as the 'core' set, for reporting on the state of the environment across Commonwealth and State and Territory jurisdictions. The core indicators have been developed by the Australian and New Zealand Environment and Conservation Council (ANZECC) through an extensive consultation process involving both government agencies and the general public.

State of the Environment Reporting

State of the environment (SoE) reporting is a system for delivering useful information and assessments about the environment to all parts of Australian society including the public, government, industry, and non-government organisations. SoE reports facilitate environmentally related decision-making and contribute significantly to education about the environment and natural resources. Importantly, SoE reporting enhances the quality, accessibility and relevance of data relating to ecologically sustainable development (ESD), and enables progress towards achieving the broader goals of ESD to be monitored.

State of the environment reporting:

- *is scientifically credible.* The information it delivers is objectively based on the best available scientific data and advice;
- *identifies trends, important issues and emerging issues* in the environment. This makes it a valuable tool for decision-makers such as managers, industry or policy developers;
- *assesses efforts to deal with important environmental issues.* This information enables performance evaluation on environmental management and assists strategic planning;
- *is regular.* The frequency of reporting may vary depending upon the issue and the jurisdiction, but the aim is to produce a series of reports that track progress over time; and
- *is relevant to the goals of ecologically sustainable development.*

Who reports on the state of the environment?

Australian governments and the New Zealand government are generally committed to reporting on the state of the environment, although the formal mechanisms vary. At the national level, the recently passed *Environment Protection and Biodiversity Conservation (EPBC) Act 1999*, requires a State of the Environment Report to be prepared by the Commonwealth on the Australian jurisdiction every five years. More than half of Australia's State and Territory governments also have a legislative requirement to prepare regular SoE reports. Many local governments now report on the state of the environment, and in New South Wales this is a legislative requirement. A number of corporations and utilities also produce corporate environment reports. Appendix 1 lists some recent state of the environment reports and gives information on how to obtain further information.

Environmental indicators

The environment is complex, and discerning environmental trends can be difficult. Environmental indicators help track changes in the environment by selecting key measures – which may be physical, chemical, biological or socio-economic – that provide useful information about the whole system. Using indicators,

it is possible to evaluate the fundamental condition of the environment without having to capture the full complexity of the system. Indicators are based on the best scientific understanding currently available so that changes in these simple measures can be related to more complex environmental trends. When time series data for an indicator show a trend, then there is a need to provide some interpretation of the trend and its implications. Therefore an indicator must be backed by a sound theoretical framework so that accurate interpretations can be made.

The concentration of ozone depleting substances in the atmosphere is a good example of an indicator. The complex chemistry of stratospheric ozone depletion need not be understood in order to use this indicator. We know that increases in the concentration of ozone depleting substances are harmful to the stratospheric ozone layer, while decreases show that efforts to protect the ozone layer are succeeding.

Why develop environmental indicators?

Environmental indicators simplify state of the environment reporting in two important ways. Firstly, indicators have a well-understood meaning and can be measured regularly. Trends in the indicators are thus readily interpreted to yield valuable information about important aspects of the environment. Secondly, environmental indicators can be an aid to communication. They allow information about the environment to be communicated effectively. As users of information about the environment become more familiar with the agreed indicators, they will be able to absorb this information more quickly. Thus the efficiency of decision-making should be enhanced.

Environmental indicators can also help focus and rationalise environmental monitoring programs by drawing attention to the critical measures required to evaluate environmental trends and conditions.

Core indicators

In order to improve the effectiveness of environmental reporting, all jurisdictions are developing environmental indicators. ANZECC has developed a set of core environmental indicators that are applicable to both national and State/Territory state of the environment reporting. This work may also enable local governments and communities to better integrate their state of the environment reporting with that occurring at the State/Territory and national scales. The indicators are listed by theme and issue in Table 1.

All jurisdictions are currently monitoring a number of the indicators identified in this paper. A suite of core indicators will assist each jurisdiction to further develop its environmental monitoring, and to help build a national picture of trends and the condition of our environment. The core indicators may be supplemented in each jurisdiction by additional indicators to accommodate particular management, scale or environmental issues as necessary.

Status of core indicators

This report identifies a set of core indicators that are scientifically valid and available for application in all jurisdictions choosing to adopt them. The scientific and technical basis for these indicators is based largely on the work commissioned by Environment Australia (see Appendix 2) and the experience gained in state of the environment reporting in each jurisdiction.

Some of the core indicators represent measures for which complete data are currently not available, or for which available data are not consistent across jurisdictions. The need to monitor core indicators consistently will be a factor in regular reviews of existing monitoring programs and establishing new monitoring programs.

It should be noted that at this stage, some important issues are not measured by core indicators because of data limitations, scientific uncertainty or a lack of robust measurement techniques. As a consequence, it is not yet

possible to derive a complete picture of Australia's environment using the core environmental indicators alone. Hence it is expected that the core indicators will evolve further over time as these problems are overcome.

In New Zealand, the Ministry for the Environment is co-ordinating the development of a core set of national environmental performance indicators under the Environmental Performance Indicators (EPI) Program. The purpose of the EPI Program is to develop and use indicators to measure and report on how well New Zealand is looking after its environment. The Ministry has worked with a wide range of different people and organisations to develop and confirm their core indicators and a summary of their progress to date is listed in Appendix 3.

Criteria for selecting core indicators

Not all of the environmental measures or indicators currently in use are suitable as core indicators. For example, some measures are important for a particular purpose in a specific region but lack national significance.

Core indicators were selected on the basis that they should:

- reflect a valued element of the environment or an important environmental issue;
- have relevance to policy and management needs;
- be useful for tracking environmental trends at a range of spatial scales from the local to the continental;
- be scientifically credible;
- be cost effective;
- serve as a robust indicator of environmental change;
- be readily interpretable;
- be monitored regularly, either by existing programs or by new programs that might be established in the future at reasonable cost; and
- reflect national programs and policies.

Ideally, indicators should satisfy all of these criteria. However, in some cases indicators which rate highly against some criteria have been selected despite their not fully satisfying other criteria. The indicator descriptions in Part Two provide details of an indicator's performance against these selection criteria.

Links to other relevant work

Core indicators for reporting on the state of the environment are related to a number of other important national Australian projects. These include:

- the *National Greenhouse Strategy*;
- the National Land and Water Resources Audit;
- the Australian Bureau of Statistics (ABS) environmental accounting project;
- the Montreal Criteria and Indicators for Sustainable Forest Management;
- the National Collaborative Project on Indicators for Sustainable Agriculture (NCPISA);
- the National Environment Protection Measures (NEPMs) being developed by the National Environment Protection Council;
- the *National Strategy for the Conservation of Australia's Biological Diversity*;
- Australia's Oceans Policy; and
- Sustainability Indicators (EA and BRS).

Core indicators do not duplicate this work but rather enhance or complement these broader strategies and programs. Development of the core indicators has drawn on work being done in other areas. Less commonly, a core indicator may directly reflect an indicator developed as part of another program, for example the NCPISA indicator on wind erosion. In other cases, the core indicators will feed into work being done elsewhere.

Because of its comprehensive scope, state of the environment reporting can help integrate and focus work done in particular sectors.

Table 1: Summary of the core indicators

Theme / Issue	ANZECC Code	Core Indicator	C,P,R	Page No.s
ATMOSPHERE				
Climate Variability	A 1	Southern Oscillation Index	C	13
	A 2	Daily and extreme rainfall	C	14
	A 3	Average maximum and minimum temperatures	C	15
Enhanced Greenhouse Effect	A 4	Greenhouse gas atmospheric concentrations	C	16
	A 5	Annual greenhouse gas emissions	P	17
Stratospheric Ozone	A 6	Concentration of ozone depleting substances in the atmosphere	P	18
	A 7	Stratospheric ozone concentration	C	19
	A 8	Recovery and destruction of ozone depleting substances	R	20
	A 9	Ultra-violet radiation levels at the surface	C	21
Outdoor Air Quality	A 10	Exceedences of NEPM Air Quality Standards for carbon monoxide concentrations	C	22
	A 11	Exceedences of NEPM Air Quality Standards for ozoneconcentrations (photochemical smog)	C	22
	A 12	Exceedences of NEPM Air Quality Standards for lead concentrations	C	23
	A 13	Exceedences of NEPM Air Quality Standards for nitrogen dioxide concentrations	C	23
	A 14	Exceedences of NEPM Air Quality Standards for sulfur dioxide concentrations	C	24
	A 15	Exceedences of NEPM Air Quality Standards for particles concentrations	C	25
	A 16	Emission of air pollutants	P	25
BIODIVERSITY				
Threatening Processes	BD 1	Native vegetation clearing	P	27
	BD 2	Aquatic habitat destruction	P	28
	BD 3	Fire regimes	P	29
	BD 4	Introduced species	P	30
	BD 5	Species outbreaks	C	31
Loss of Biodiversity	BD 6	Extinct, endangered and vulnerable species and ecological communities	C	32
	BD 7	Extent and condition of native vegetation	C	33
	BD 8	Extent and condition of aquatic habitats	C	34
	BD 9	Populations of selected species	C	35
Biodiversity Conservation Management	BD 10	Terrestrial protected areas	R	36
	BD 11	Marine and estuarine protected areas	R	37
	BD 12	Recovery plans	R	38
	BD 13	Area revegetated	R	39
LAND				
Land Use and Management	L 1	Changes in land use	P, R	41
Erosion	L 2	Potential for erosion	P	42
	L 3	Wind erosion from high wind events	C	43
Salinity	L 4	Area of rising watertables	C	43
	L 5	Area affected by salinity	C	44
Acidity	L 6	Area affected by acidity	C	45
Contamination	L 7	Exceedences of the Maximum Residue Levels in food and produce	C	46

Table 1: Summary of the core indicators *(continued)*

Theme / Issue	ANZECC Code	Core Indicator	C, P, R	Page No.s
INLAND WATERS				
Groundwater	IW 1	Groundwater extraction versus availability	C	47
	IW 2	Exceedences of groundwater quality guidelines	C	48
Surface Water	IW 3	Extent of deep-rooted vegetation cover by catchment	P	49
	IW 4	Surface water extraction versus availability	P	50
	IW 5	Environmental Flows Objectives	R	50
	IW 6	Discharges from point sources	P	51
	IW 7	Surface water salinity	C	51
	IW 8	Exceedences of surface water quality guidelines	C	52
	IW 9	Freshwater algal blooms	C	53
	IW 10	Waste water treatment (inland waters)	R	54
	IW 11	Waste water re-use (inland waters)	R	55
Aquatic Habitats	IW 12	Vegetated streamlength	P	56
	IW 13	River health (AUSRIVAS)	C	57
	IW 14	Extent and condition of wetlands	C	58
	IW 15	Estimated freshwater fish stocks	C	59
ESTUARIES & the SEA				
Marine Habitat and Biological Resources	E+S 1	Changes in coastal use	P	60
	E+S 2	Disturbance of marine habitat	P	61
	E+S 3	Total seafood catch	P	61
	E+S 4	Estimated wild fish stocks	C	62
Estuarine and Marine Water Quality	E+S 5	Coastal discharges	P	62
	E+S 6	Maritime pollution incidents	P	63
	E+S 7	Exceedences of marine and estuarine water quality guidelines	C	64
	E+S 8	Bio-accumulated pollutants	C	65
	E+S 9	Algal blooms in estuarine and marine environments	P, C	66
	E+S 10	Waste water treatment (coastal waters)	R	67
	E+S 11	Disturbance of potential acid sulfate soils	P	67
Global Processes	E+S 12	Sea level	C	68
	E+S 13	Sea surface temperature	C	69
HUMAN SETTLEMENTS				
Energy	HS 1	Energy use	P	71
	HS 2	Energy sources	P, R	72
Water	HS 3	Exceedences of drinking water quality	C	73
Demographics	HS 4	Urban green space	C	74
	HS 5	Residential density	C	75
	HS 6	Population distribution and number of people per dwelling	P	76
	HS 7	Visitor numbers	P	77
Transport	HS 8	Public transport use	C	77
	HS 9	Fuel consumption per transport output	P	78
Waste	HS 10	Solid waste generation and disposal	P	79
Community attitudes and actions	HS 11	Community attitudes and actions	R	80

Key:
C, P, R = condition, pressure, response type of indicator

Some of the key relevant work in New Zealand with links to the New Zealand Environmental Performance Indicators Program are:

- the New Zealand Biodiversity Strategy;
- environmental statistics work by Statistics New Zealand;
- the National Agenda for Sustainable Water Management;
- the Sustainable Land Management Strategy;
- the Annual Survey of Local Authorities;
- regional and district councils state of the environment monitoring; and
- the Hazardous Waste Program.

The Condition–Pressure–Response framework

Frameworks are important for organising and presenting information and defining the range of issues to be considered. They are less important for selecting indicators. Indicators are chosen on the basis of the best available scientific understanding, and can be placed in a number of alternative frameworks to present and organise information.

The condition-pressure-response (also referred to as pressure-state-response) framework is used for state of the environment reporting in most Australian jurisdictions. The concept was originally developed by the OECD, and has been widely adopted in a modified form by OECD countries and a wide range of other organisations. Some jurisdictions have further modified the framework with the addition of implications and/or drivers.

The condition-pressure-response framework organises information into three broad categories.

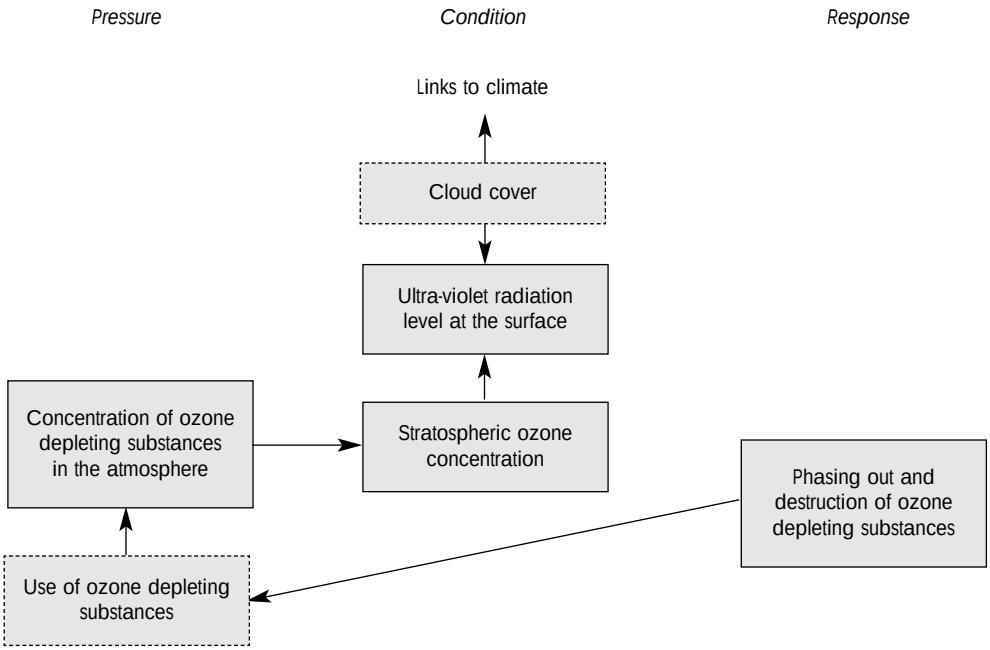
- information about the *condition* of the environment. That is, the quality of the environment and the functioning of important environmental processes;
- information about human activities that affect the environment. These are called *pressures*. Pressures do not necessarily imply harm, especially if the activity is appropriately managed; and
- information about human efforts to address environmental issues. These are called *responses*.

The core indicators have been classified as condition, pressure or response indicators to demonstrate how they can be used for reporting on the state of the environment using the condition-pressure-response framework.

There are many relationships between human activities (“pressures”) and the condition of the environment. However, these relationships can be complex and sometimes difficult to demonstrate, as the condition of the environment typically depends upon a wide range of natural as well as human induced factors. Dryland salinity, while a relatively straightforward example, illustrates this. In some places people have cleared native vegetation (a pressure) and replaced it with annual crops, which use far less water. As a result, the level of groundwater rises. These groundwaters are often salty, and when they reach the surface the land also becomes salty (a condition). At the same time, much land is naturally salt affected, so not all dryland salinity is due to human activity. In addition, there can be a delay of several decades between clearing native vegetation and the onset of dryland salinity.

Although many of the core indicators are linked, the issue of relationships and causality between indicators is often complex. Detailing all of the links between all of the core indicators is beyond the scope of this report. However, the diagram shown by Figure 1 demonstrates some of these links by using indicators relating to stratospheric ozone depletion. As noted above, there are some important conditions, pressures and responses for which it has not been possible to develop indicators. These are identified in Figure 1 by placing them in a box with dashed outlines.

Figure 1: Some of the links between core indicators relating to stratospheric ozone depletion



[Note: This simplified diagram is not intended to show all links. Links are not necessarily direct causal relationships. Dotted boxes denote conditions, pressures or responses for which indicators have not been developed.]

Further Work

The work in producing the core set of indicators has highlighted the uncertainty of our knowledge in many areas of the environment. The issues for which no core indicators could be identified require further conceptual development. For example, more research is required into the question of biodiversity surrogates, to more fully test assumptions, and into ecosystem monitoring. All indicators need to be reviewed continually to improve definition, usage and interpretation. Several of the core indicators identified in this report require further development before they can be fully implemented – in such cases the need for a second stage of implementation has been noted. Further development may relate to data collection techniques or other methodology or interpretation issues.

Where to from here

This report therefore identifies a set of core indicators that are scientifically valid and available for application in all jurisdictions choosing to adopt them. ANZECC recognises that the core set will continue to evolve as the suitability and applicability of the indicators are demonstrated through use by the Australian community. In the next phase of this work, the ANZECC SoE Reporting Task Force will review the core set regarding methodologies and protocols for their application and interpretation. This review will provide a basis for a practical and consistent approach to implementing the core indicators across jurisdictions.

PART TWO: THE INDICATORS IN DETAIL

The following provides an explanation for each part of an indicator entry

ANZECC Core Indicator Number → **(ANZECC: A 1)** **SOUTHERN OSCILLATION INDEX** **[CONDITION]**

The Southern Oscillation Index (SOI) is a well-established measure of variations in large-scale surface air pressure patterns across the Pacific.

Type of indicator

Why is this indicator important?	Climate variability is a key factor in the evolution, functioning and management of Australia's ecosystems. The high variability of Australia's climate is due to the El Niño – Southern Oscillation (ENSO) phenomenon, which is a major, if not the largest, source of variation in the global climate system. Any anthropogenically-induced changes in the climate must be evaluated against the baseline of interannual variability.
Why was this indicator selected?	There is a well-established correlation between the SOI and variations in rainfall across Australia. Sustained values of the SOI below -10 indicate an ENSO event, which generally corresponds to a reduction in storm frequency north of Australia and below normal rainfall across much of northern and eastern Australia. When the SOI has sustained values above 10, the rainfall across much of Australia tends to be above normal, corresponding to an anti-ENSO event.
Current monitoring status	The SOI is monitored by the Bureau of Meteorology, with records extending back to the 19th century.
Development & interpretation issues	Continuing research is needed to refine the interpretation of the SOI and its links to Australian climate. A significant issue is the decadal-scale variability of the SOI. Methodology is well established.
Cross-reference to indicator(s) in reports listed in Appendix 2	*[Manton & Jasper: A 1.1]*

ATMOSPHERIC INDICATORS

Suggested core environmental indicators for the atmosphere are grouped under four issues: climate variability, enhanced greenhouse effect, stratospheric ozone, and outdoor air quality.

(i) Climate Variability

Three indicators are suggested for climate variability. They focus mainly on the variability of Australia's climate, which is comparatively high. This variability is important in its own right, regardless of any possible anthropogenic effects on the climate.

(ii) Enhanced Greenhouse Effect

Two suggested indicators relate to the enhanced greenhouse effect. An additional indicator relating to progress in implementing the National Greenhouse Strategy response measures (against Kyoto targets) needs to be developed.

(iii) Stratospheric Ozone

Three core indicators are suggested for stratospheric ozone: one relating to the concentration of ozone depleting substances in the atmosphere, one to stratospheric ozone concentrations, and one to the destruction of ozone depleting substances.

(iv) Outdoor Air Quality

Seven core indicators are suggested for outdoor air quality. Six of these follow the draft National Environment Protection Measures for ambient air quality and relate to the concentration of various pollutants that are potentially harmful to human health. The last core indicator measures emissions of air pollutants.

Motor vehicles are a major source of air pollutants, and emissions are strongly influenced by factors such as the age of the vehicle fleet, driver behaviour, and vehicle maintenance. An indicator covering these aspects would be a valuable addition to the core indicator set, but it was not possible to develop an indicator that met the selection criteria. However, part of this information should be covered by the indicator on emissions of air pollutants (ANZECC: A16) as the National Pollutant Inventory (NPI) includes estimates of emissions from transport-related activities.

Indoor air quality is recognised as an important issue. Most Australians spend up to ninety percent of their time indoors, where the pollutants to which they are exposed can be very different to those in the air outside. However, it has not been possible to find environmental indicators for indoor air quality which satisfy the selection criteria for core environmental indicators.

ISSUE: Climate variability

(ANZECC: A 1) **SOUTHERN OSCILLATION INDEX** **[CONDITION]**

The Southern Oscillation Index (SOI) is a well-established measure of variations in large-scale surface air pressure patterns across the Pacific.

Why is this indicator important?	Climate variability is a key factor in the evolution, functioning and management of Australia's ecosystems. The high variability of Australia's climate is due to the El Niño – Southern Oscillation (ENSO) phenomenon, which is a major, if not the largest, source of variation in the global climate system. Any anthropogenically-induced changes in the climate must be evaluated against the baseline of interannual variability.
Why was this indicator selected?	There is a well-established correlation between the SOI and variations in rainfall across Australia. Sustained values of the SOI below -10 indicate an ENSO event, which generally corresponds to a reduction in storm frequency north of Australia and below normal rainfall across much of northern and eastern Australia. When the SOI has sustained values above 10, the rainfall across much of Australia tends to be above normal, corresponding to an anti-ENSO event.
Current monitoring status	The SOI is monitored by the Bureau of Meteorology, with records extending back to the 19th century.
Development & interpretation issues	Continuing research is needed to refine the interpretation of the SOI and its links to Australian climate. A significant issue is the decadal-scale variability of the SOI. Methodology is well established.

[Manton & Jasper: A 1.1]

(ANZECC: A 2) **DAILY AND EXTREME RAINFALL** **[CONDITION]**

The average daily rainfall for each year and season, together with the percentage of the area with annual rainfall below decile 1 or above decile 9.

Why is this indicator important?	Water is a limiting factor in agricultural and other biological systems. Australia's highly variable rainfall thus has substantial effects on natural ecosystems and human activities. An understanding of variations in rainfall is an important adjunct for interpreting several inland waters and land indicators.
Why was this indicator selected?	Average daily rainfall is a direct measure of the variations in rainfall. Areas receiving rainfall below decile 1 are generally experiencing drought conditions, while those with rainfall above decile 9 are experiencing high rainfall conditions. Trends in these values will indicate whether we are moving to periods of more droughts and floods.
Current monitoring status	Average daily rainfall is monitored by the Bureau of Meteorology, and records are available for the entire twentieth century.
Development & interpretation issues	None. Methodology is well established.

[Manton & Jasper: A 1.4 & 1.6]

(ANZECC: A 3) AVERAGE MAXIMUM AND MINIMUM TEMPERATURES [CONDITION]

The mean of (i) the ten percent of highest and (ii) ten percent of lowest temperatures recorded over each year and season, together with the percentage of the area with annual average temperatures above decile 9 or below decile 1.

Why is this indicator important?

Measures of extremes are important due to their maximum biological impact, which will not be explained by averages. For example, due to the impact of frost on many crops, the interannual variability of the minimum temperature is of great interest to agriculture. Because of the potential for global warming due to the enhanced greenhouse effect, there is much interest in reporting the annual surface temperature across Australia. There is some suggestion that the maximum and minimum temperatures will not necessarily change at the same rate. It is therefore appropriate to report on both the maximum and over-night minimum temperatures

Why was this indicator selected?

This indicator is a direct measure of the condition.

Current monitoring status

Average temperatures are monitored by the Bureau of Meteorology, with records corrected for site changes, etc, back to 1957.

Development & interpretation issues

There is continuing comment on the expected bias in national temperature trends due to the inclusion of observations from cities, where the "heat island" effect tends to lead to temperatures above those in the surrounding country-side. The national temperature trends are computed by ignoring city-based measurements.

Methodology is well established.

[Manton & Jasper: A 1.5]

ISSUE: Enhanced greenhouse effect

(ANZECC: A 4) **GREENHOUSE GAS ATMOSPHERIC CONCENTRATIONS** **[CONDITION]**

Annual average atmospheric concentrations of carbon dioxide, methane, nitrous oxide, halocarbons, and substitute halocarbons.

Why is this indicator important?	The greenhouse gases controlled under Annex A of the Kyoto Protocol are carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulphur hexafluoride (SF_6). The concentration of greenhouse gases in the atmosphere has risen over the last century. The balance of evidence suggests a discernible human influence on global climate. This increase in greenhouse gas concentration is almost certainly linked to changes in climate.
Why was this indicator selected?	This indicator is a direct measure of the condition.
Current monitoring status	Greenhouse gas concentrations are jointly monitored at Cape Grim (Tasmania) by the Bureau of Meteorology and the CSIRO Atmospheric Research. Because greenhouse gases are well mixed in the atmosphere, these point measures represent global averages.
Development & interpretation issues	None. Methodology is well established.

[Manton & Jasper: A 1.10]

(ANZECC: A 5) ANNUAL GREENHOUSE GAS EMISSIONS [PRESSURE]

Annual greenhouse gas emissions, in carbon dioxide equivalents, in total and by sector. Following the National Greenhouse Gas Inventory (NGGI), sectors are: stationary energy, transport, fugitive emissions from fuel, industrial processes, solvents, agriculture, land use change and forestry, and waste. The greenhouse gases controlled under Annex A of the Kyoto Protocol are carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulphur hexafluoride (SF_6).

Why is this indicator important?	Human activities have led to an increase in the atmospheric concentration of greenhouse gases over the last century. Australia is committed to restricting the increase in its greenhouse gas emissions to 8 percent above 1990 levels between 2008 and 2012.
Why was this indicator selected?	This indicator is a direct measure of the pressure, and satisfies all selection criteria, although interpretation of land use change requires further research.
Current monitoring status	This indicator is monitored on a national scale by the National Greenhouse Gas Inventory.
Development & interpretation issues	Methods for calculating greenhouse gas emissions are being improved. There are considerable uncertainties in some estimates, particularly for land clearing. Adopt established NGGI methodology.

[Manton & Jasper: A 1.11]

ISSUE: Stratospheric ozone

(ANZECC: A 6)	CONCENTRATION OF OZONE DEPLETING SUBSTANCES IN THE ATMOSPHERE	[PRESSURE]

Annual mean atmospheric concentrations of ozone depleting substances, including chlorofluorocarbons (e.g. CFC-11, CFC-12 and CFC-113 etc), hydrochlorofluorocarbons (eg. HCFC-21 and HCFC-22 etc), halons (e.g. Halon 1211 etc), methyl chloroform, carbon tetrachloride, and methyl bromide.

Why is this indicator important?	It is now well established that the depletion of stratospheric ozone is linked to the presence of reactive chlorine and bromine, transported from the surface in the form of CFCs, chlorinated solvents and halons. These ozone depleting substances (ODSs) have very long lifetimes in the atmosphere. Under the Montreal Protocol, CFCs and other ODSs are being phased out as quickly as possible. To expedite this process, the chemical industries have developed replacement gases. In the short term, hydrochlorofluorocarbons (HCFCs) are replacing the CFCs. However, the HCFCs still contain chlorine, and so they will eventually be replaced by hydrofluorocarbons (HFCs) and other non-ozone depleting substances.
Why was this indicator selected?	This indicator is a direct measure of the pressure. Large interannual variations in stratospheric ozone concentrations mean that concentrations of ODSs are more sensitive indicators of change than ozone concentrations.
Current monitoring status	Concentrations of ODSs are jointly monitored at Cape Grim (Tasmania) by the Bureau of Meteorology and the CSIRO Division of Atmospheric Research. Because ODSs are well mixed in the atmosphere, these point measures are representative of global averages.
Development & interpretation issues	None. Methodology is well established.

[Manton & Jasper: A 2.1]

(ANZECC: A 7) STRATOSPHERIC OZONE CONCENTRATION [CONDITION]

Mean annual stratospheric ozone concentration across Australia in two latitude bands – from 10° S to 22° S and from 22° S to 45 ° S – to separate trends in the tropics from those in the sub-tropics, complemented by the annual average ozone levels at the five Bureau of Meteorology sites of Darwin, Brisbane, Perth, Melbourne and Macquarie Island.

Why is this indicator important?	The level of UV radiation reaching the ground from the sun is controlled largely by the concentration of stratospheric ozone. UV radiation can damage living matter, and affects all biological systems. In humans, UV radiation is linked to the incidence of skin cancer, cataract eye disease, and even immune system suppression.
Why was this indicator selected?	This indicator is a direct measure of the condition. Trends in ozone will be analysed for signs of the success of the Montreal Protocol in phasing out ozone depleting substances (ODSs). However, the life-time of ODSs in the atmosphere is in the order of decades, and so the global concentration of ozone is expected to continue to fall for some time. Full recovery of the ozone layer will require some decades beyond the time that the supply and emission of ODSs is stopped.
Current monitoring status	Global-scale daily analyses are produced by the Bureau of Meteorology on a 2.5° latitude by 2.5° longitude grid, using satellite data, with in situ Dobson spectrophotometer measurements at major centres in Australia providing benchmark and calibration data of total-column ozone. Some satellite data exists back to 1979.
Development & interpretation issues	Trends at specific sites or averaged across Australia will need to be interpreted carefully because local ozone levels are substantially affected by general meteorological conditions. The quality control on the early Dobson data requires further work. Methodology is established.

[Manton & Jasper: A 2.2]

(ANZECC: A 8) **RECOVERY AND DESTRUCTION OF OZONE DEPLETING SUBSTANCES** **[RESPONSE]**

The quantity of ozone depleting substances destroyed or reclaimed.

Why is this indicator important?	As refrigeration systems are converted, ozone depleting substances are recovered for reclamation or destruction. This indicator is both a measure of conversion to ozone friendly systems and of quantities destroyed. While there are bans on the production of ozone depleting substances, existing stocks need to be managed.
Why was this indicator selected?	This indicator shows the quantities of ozone depleting substances taken out of commission. This material is reclaimed, stored or destroyed.
Current monitoring status	Data to support this indicator will be provided by Refrigerant Reclaim Australia, an industry association that has undertaken to recover existing stocks of ozone depleting substances. Annual data (independently audited) are provided on total quantities recovered and destroyed. The National Halon Bank data is also relevant.
Development & interpretation issues	None. Methodology is established.

[Manton & Jasper: A 2.9]

(ANZECC: A 9) **ULTRA-VIOLET RADIATION LEVELS AT THE SURFACE** **[CONDITION]**

The level of UV radiation at the surface, reported in units of minimal erythemal dose (MED).

Why is this indicator important?	Australia has extreme levels of solar UV radiation because of its location in the middle and low latitudes in the Southern Hemisphere and its relatively clean and cloudless skies. The shorter wavelength UVB radiation is the most harmful to health. In humans, UVB radiation is linked to the incidence of skin cancer, cataract eye disease and even immune suppression. Ozone absorbs UV particularly in the UVB part of the spectrum and thus the effect of stratospheric ozone depletion is to increase UVB at the surface.
Why was this indicator selected?	This indicator is a direct measure of the condition. The recommended unit (MED) accounts for the erythemal response to different wavelengths of UV radiation, and effectively integrates in time to estimate the total exposure required to induce a perceptible erythemal response in people with a particular skin type.
Current monitoring status	The Australian Radiation Laboratory makes observations at 18 sites around Australia. There is a proposal to expand this network.
Development & interpretation issues	Variations in cloud cover can affect short-term patterns in UV radiation levels at the surface. Methodology is established.

[Manton & Jasper: A 2.3 (also see 2.8)]

ISSUE: Outdoor air quality

(ANZECC: A 10) **EXCEEDENCES OF NEPM AIR QUALITY STANDARDS FOR CARBON MONOXIDE CONCENTRATIONS** **[CONDITION]**

The maximum, minimum, 5th percentile, 95th percentile and median carbon monoxide concentrations in airsheds specified by the NEPM Air Quality standards, together with the number of days on which the NEPM standard for carbon monoxide is exceeded. This indicator will follow the NEPM.

Why is this indicator important?	Carbon monoxide can have harmful effects on health, which depend upon exposure time and carbon monoxide concentration. Impacts are related to carboxyhaemoglobin, which irreversibly reduces the carriage of oxygen to organs in the body, in blood. Exposure at low levels can lead to increased occurrence of cardiovascular disease symptoms.
Why was this indicator selected?	The selected parameters reflect the distribution of carbon monoxide concentrations over time.
Current monitoring status	This indicator is monitored in all large cities, and in selected smaller urban areas.
Development & interpretation issues	Meteorological conditions, atmospheric chemistry and siting of monitoring stations can affect the value of this indicator. Adopt established NEPM methodology.

[Manton & Jasper: A 3.1 & 4.4]

(ANZECC: A 11) **EXCEEDENCES OF NEPM AIR QUALITY STANDARDS FOR OZONE CONCENTRATIONS (PHOTOCHEMICAL SMOG)** **[CONDITION]**

The maximum, minimum, 5th percentile, 95th percentile and median ozone concentrations in airsheds specified by the NEPM Air Quality standards, together with the number of days on which the NEPM standard for ozone is exceeded. This indicator will follow the NEPM.

Why is this indicator important?	Ground level ozone can have harmful effects on health, which depend upon exposure time and concentration. The health effects of ozone vary from minor changes in lung function to aggravation of existing respiratory and cardiovascular disease, which may lead to an increase in hospital admissions for these conditions. Increases in daily mortality have also been associated with exposure to ozone.
Why was this indicator selected?	The selected parameters reflect the distribution of ozone concentrations over time.
Current monitoring status	This indicator is monitored in all large cities, and in selected smaller urban areas.
Development & interpretation issues	Meteorological conditions, atmosphere chemistry and siting of monitoring stations can affect the value of this indicator. Adopt established NEPM methodology.

[Manton & Jasper: A 3.2 & 4.5]

(ANZECC: A 12)	EXCEEDENCES OF NEPM AIR QUALITY STANDARDS FOR LEAD CONCENTRATIONS	[CONDITION]

Lead concentrations in airsheds specified by the NEPM Air Quality standard. This indicator will follow the NEPM.

Why is this indicator important?	Lead can have harmful effects on health, which depend upon exposure time and concentration. The major health effect of lead exposure is on the central nervous system, as demonstrated by decreased IQ with increased blood levels. Children exposed to lead are especially at risk.
Why was this indicator selected?	The selected parameters reflect the distribution of lead concentrations over time.
Current monitoring status	This indicator is monitored in all large cities, and in selected smaller urban areas.
Development & interpretation issues	Meteorological conditions and siting of monitoring stations can strongly affect the value of this indicator. Adopt established NEPM methodology.

[Manton & Jasper: A 3.3 & 4.3]

(ANZECC: A 13)	EXCEEDENCES OF NEPM AIR QUALITY STANDARDS FOR NITROGEN DIOXIDE CONCENTRATIONS	[CONDITION]

The maximum, minimum, 5th percentile, 95th percentile and median nitrogen dioxide concentrations in airsheds specified by the NEPM Air Quality standards, together with the number of days on which the NEPM standard for nitrogen dioxide is exceeded. This indicator will follow the NEPM.

Why is this indicator important?	Nitrogen dioxide can have harmful effects on health, which depend upon exposure time and concentration. The health effects of nitrogen dioxide include decreases in lung function, increased susceptibility to respiratory infection and aggravation of existing respiratory and cardiovascular disease. Exacerbation of asthma is also associated with exposure to nitrogen dioxide. Increases in daily mortality have been shown to be associated with ambient concentrations of nitrogen dioxide. It can also exacerbate the effects of other pollutants such as ozone and sulphur dioxide.
Why was this indicator selected?	The selected parameters reflect the distribution of nitrogen dioxide concentrations over time.
Current monitoring status	This indicator is monitored in all large cities, and in selected smaller urban areas.
Development & interpretation issues	Meteorological conditions, atmosphere chemistry and siting of monitoring stations can strongly affect the value of this indicator. Adopt established NEPM methodology.

[Manton & Jasper: A 3.4 & 4.6]

(ANZECC: A 14) **EXCEEDENCES OF NEPM AIR QUALITY STANDARDS FOR SULFUR DIOXIDE CONCENTRATIONS** **[CONDITION]**

The maximum, minimum, 5th percentile, 95th percentile and median sulfur dioxide concentrations in airsheds specified by the NEPM Air Quality standards, together with the number of days on which the NEPM standard for sulfur dioxide is exceeded. This indicator will follow the NEPM.

Why is this indicator important?	Sulfur dioxide can have harmful effects on health, which depend upon exposure time and concentration. The health effects of sulfur dioxide are associated with respiratory disease and asthma. Increases in daily mortality have been associated with exposure to sulfur dioxide. Asthmatics are a particularly susceptible group.
Why was this indicator selected?	The selected parameters reflect the distribution of sulfur dioxide concentrations over time.
Current monitoring status	This indicator is monitored near major sources of sulfur dioxide.
Development & interpretation issues	Sulfur dioxide comes mainly from burning fossil fuels and smelting processes. The fuels used in Australia are generally low in sulfur, and sulfur dioxide is not a significant problem in most urban airsheds. Developing an appropriate monitoring strategy for sulfur dioxide requires careful consideration of the location of point sources. Adopt established NEPM methodology.

[Manton & Jasper: A 3.5 & 4.1]

(ANZECC: A 15) **EXCEEDENCES OF NEPM AIR QUALITY STANDARDS FOR PARTICLES CONCENTRATIONS** **[CONDITION]**

The maximum, minimum, 5th percentile, 95th percentile and median particles (PM10) concentrations in airsheds specified by the NEPM Air Quality standards, together with the number of days on which the NEPM standard for particles is exceeded. This indicator will follow the NEPM.

Why is this indicator important?	Particles can have harmful effects on health, which depend upon exposure time and concentration. The main health impacts that have been associated with particles are increases in daily mortality. Aggravation of existing respiratory and cardiovascular disease (including asthma) leading to increased hospital admissions and medication use has also been associated with exposure to particles, even at low levels.
Why was this indicator selected?	The selected parameters reflect the distribution of particles concentrations over time.
Current monitoring status	This indicator is monitored in all large cities, and in selected smaller urban areas.
Development & interpretation issues	Meteorological conditions and siting of monitoring stations can strongly affect the value of this indicator. There is ongoing discussion about the merits and technical feasibility of measuring concentrations of finer particles. Adopt established NEPM methodology.

[Manton & Jasper: A 3.6 & 4.2]

(ANZECC: A 16) **EMISSION OF AIR POLLUTANTS** **[PRESSURE]**

Emission of air pollutants listed in the National Pollutant Inventory in each air shed. Important pollutants include benzene, carbon monoxide, lead, oxides of nitrogen, particles, sulfur dioxide, and volatile organic compounds.

Why is this indicator important?	The emission of pollutants into the atmosphere leads to concentrations of gases and particles that have deleterious effects. These listed pollutants can be injurous to health.
Why was this indicator selected?	This indicator is a direct measure of the pressure.
Current monitoring status	Some monitoring takes place in all jurisdictions. Increasing quantities of data will become available as the National Pollutant Inventory is implemented.
Development & interpretation issues	The relationship between emissions and atmospheric concentration of pollutants is complex, because of chemical reactions and transport and dispersion. However, the relationship is understood and can be modelled. Aggregate emissions will be estimated by the National Pollutant Inventory, but methods are still being developed. Adopt established NPI methodology.

[Manton & Jasper: A 3.12]

BIODIVERSITY INDICATORS

Biodiversity – the variety of all life forms – is generally considered at three levels: ecosystem diversity, species diversity, and genetic diversity. The condition indicators presented here relate to these three principal levels of biodiversity:

- "extent and condition of native vegetation" and "extent and condition of marine habitats" relate mainly to ecosystem diversity,
- "extinct, endangered and vulnerable species" relate mainly to species diversity, and
- "populations of selected species" is a surrogate indicator relating to genetic diversity.

Biological diversity is extremely difficult to quantify, and these indicators fall short of capturing its full range. However, they are the best practical options available at present.

All three levels of biodiversity are affected by a range of threatening processes. The pressure indicators presented here relate to these threatening processes: clearing of native vegetation and destruction of marine habitat, altered fire regimes and introduced species. Pollution, also identified as a threatening process in the *National Strategy for the Conservation of Australia's Biological Diversity*, is addressed by indicators within the atmosphere, inland waters, and estuaries and the sea themes. The size and distribution of the human population, cited by the National Strategy as an "underlying cause" of loss of biodiversity (i.e. via demand and consumption of space and resources), is addressed by the indicators for human settlements.

Australians have responded in many ways to loss of and threats to biodiversity. The response indicators selected relate to development of a reserve system, recovery plans for endangered species, and revegetation. Many responses are not readily quantified, and it has not been possible to capture all responses in this set of indicators. Significant omissions include off-reserve conservation, and effective management for sustainable resource use, such as standards for agricultural best practice.

The proposed core indicators for biodiversity have been selected for their usefulness in state of the environment reporting. They are intended to measure changes in biological diversity, human activities affecting it, and our response to loss of biodiversity. The indicators also have value for measuring the progress of the *National Strategy for the Conservation of Australia's Biological Diversity*. Although the core indicators are not designed specifically to measure the performance of the National Strategy, links have been noted where appropriate.

ISSUE: Threatening processes

(ANZECC: BD 1) **NATIVE VEGETATION CLEARING** **[PRESSURE]**

Rate of clearing, in hectares per annum, of terrestrial native vegetation types, by clearing activity.

Why is this indicator important?	The National Strategy for the Conservation of Australia's Biological Diversity lists clearing of native vegetation as a threatening process. Clearing vegetation reduces the total area of habitat available to species, and can increase the risk of local extinction.
Why was this indicator selected?	This indicator is a direct measure of the threatening process.
Current monitoring status	Some estimates of the rate of clearing are available, particularly for the Intensive Landuse Zone at broad scales.
Development & interpretation issues	Australia is currently working toward an agreed, hierarchical vegetation classification through the National Vegetation Information System (NVIS) project, with an agreed methodology available in the year 2000. In the first instance, it may only be possible to report the total area of native vegetation cleared or to use very broad vegetation types. While this is useful information, it will be more valuable to know the amount of clearing by more finely classified vegetation types. The location of clearing also needs to be considered in interpreting this indicator. Methodology being developed in collaboration with the NLWRA and BRS.

[Saunders et al: *BD 2.1]*

(ANZECC: BD 2) **AQUATIC HABITAT DESTRUCTION** **[PRESSURE]**

Rate of destruction, in hectares per annum, of freshwater and marine habitats, by the types of disturbing activities (e.g. trawling through seagrass beds). Marine habitat types include algal beds, beaches and dunes, coral reefs, intertidal reefs, intertidal sand/mudflats, mangroves, saltmarshes, and seagrass. Freshwater habitat types include those found in streams, rivers, lakes and impoundments.

Why is this indicator important?

The National Strategy for the Conservation of Australia's Biological Diversity lists clearing of native vegetation as a threatening process. Destruction of freshwater and marine habitat reduces the total area of habitat available to species, and can increase the risk of local extinction.

Why was this indicator selected?

This indicator is a direct measure of the threatening process. It is the aquatic equivalent of the native vegetation clearing indicator above.

Current monitoring status

There are few estimates of the rate of freshwater and marine habitat destruction. In its current format, the NVIS will only collate marine and coastal vegetation information from Commonwealth, State and Territory agencies above the high water mark.

Development & interpretation issues

Australia is currently working toward an agreed, hierarchical vegetation classification through the National Vegetation Information System (NVIS) project, with an agreed methodology available in the year 2000. For marine habitats measurement is more difficult and natural dynamics are less well understood than for terrestrial vegetation. The location of habitat destruction also needs to be considered in interpreting this indicator.

Methodology being developed in collaboration with the NLWRA and the BRS.

[Saunders et al: *BD 2.1]*

(ANZECC: BD 3) **FIRE REGIMES** **[PRESSURE]**

Area of vegetation burnt, by frequency and intensity of burning and type of vegetation.

Why is this indicator important?

The *National Strategy for the Conservation of Australia's Biological Diversity* lists altered fire regimes as a threatening process. Much of Australia's flora and fauna has evolved with fire and relies on particular fire regimes for continued survival. Conversely, there are other fire regimes that also threaten biodiversity. With human settlement, the timing, frequency and intensity of these fires may have changed. Although fire is a part of many ecosystems, it can be damaging, since inappropriate fire regimes (for example, fires of high or low intensity that are either too frequent or insufficiently frequent) can lead to loss of native species, communities and ecosystems. Burning can promote invasion of weeds, sometimes leading to an increased fire hazard within a short time, and prescribed fires can escape to become bushfires.

Why was this indicator selected?

Understanding the effects of fire requires knowledge of the frequency and intensity with which various types of vegetation are burned. Changes in fire frequency and intensity constitute changes in fire regime. This indicator satisfies all selection criteria except ease of interpretation.

Current monitoring status

Fire intensity and frequency is routinely measured by satellite in the north of Australia. In the southern parts of Australia, some data are available from fire service and other records, but are not collated within a systematic framework across Australia.

Development & interpretation issues

Interpreting changes in fire regimes is complex and difficult. Fire plays a critical role in many Australian ecosystems, yet in most areas little is known about pre-European settlement fire regimes. Further research is required to fully understand how to interpret this indicator. It is a pressure to the extent that human activities have contributed to changes in fire regimes.

Methodology for identifying location, area and frequency of fires has been developed and is continually being refined. Methodology for identifying fire intensity requires further development. This would be the second stage of implementing this indicator.

[Saunders et al: *BD 6]*

(ANZECC: BD 4) **INTRODUCED SPECIES** **[PRESSURE]**

The distribution (and abundance where possible) of non-indigenous terrestrial, marine and freshwater species (plants, vertebrates, invertebrates, and pathogens) identified as pests. This indicator also includes displaced/translocated native species. The identified species will vary with place and time.

Why is this indicator important?

The *National Strategy for the Conservation of Australia's Biological Diversity* lists alien species and genetically modified organisms as a threat to biodiversity.Introduced species have caused extensive damage to native ecosystems. They have contributed to species extinctions by predation, habitat alteration and out-competing native species. Introduced pests also cause considerable economic losses to primary production.

Why was this indicator selected?

It is impossible to monitor the distribution and abundance of all introduced species. The only viable strategy is to concentrate on those organisms known to be causing significant problems or posing significant threats.

Current monitoring status

Some data are available. The frequency of monitoring and geographic coverage vary with species.

Development & interpretation issues

Several national strategies identify pests such as weeds and feral animals.Changes in the biogeographic range and population density of pest species will generally be of most interest. Any increase in the number of species considered pests must be carefully interpreted, as it may indicate either an increase in the number of pest species or simply an increase in our capabilities for detecting pest species. The absence of introduced species can be very important for conservation management, e.g. 'islands' of conservation significance.

Methodology is established.

[Saunders et al: *BD 3.1, 3.2 & 4.1; Hamblin: L 4.1 & 4.1A;*

Fairweather & Napier: IW 6.6; and Ward et al: *E+S 3.11]*

(ANZECC: BD 5) **SPECIES OUTBREAKS** **[CONDITION]**

The number (and identity) of native species outbreaks and the location and area affected.

Why is this indicator important?	Outbreaks, which involve large population explosions (or blooms), have been documented for a number of native species (e.g. Crown of Thorns starfish) and can threaten other native species and commercially valuable resources.
Why was this indicator selected?	This indicator is a direct measure of the condition.
Current monitoring status	Some terrestrial data are available in all jurisdictions. Marine data are mostly for major ports or for selected species (e.g. algae), or areas of special significance (e.g. the Great Barrier Reef and Ningaloo Reef off WA).
Development & interpretation issues	Care must be taken to ensure that apparent changes in the frequency of species outbreaks are not simply the result of changes in monitoring effort. Methodology is established.

[Ward et al: *E+S 3.15 and Saunders* et al: *BD 3.2]*

ISSUE: Loss of Biodiversity

(ANZECC: BD 6) **EXTINCT, ENDANGERED AND VULNERABLE SPECIES AND ECOLOGICAL COMMUNITIES** **[CONDITION]**

Number of species and ecological communities presumed extinct, endangered or vulnerable. This indicator should be reported by major group, together with the estimated number of endemic species per major group. Applies to animals and plants, both terrestrial and aquatic.

Why is this indicator important?

Extinction of species equates to a loss of species diversity.

Why was this indicator selected?

The number of species considered extinct, endangered or vulnerable is the best available surrogate for the loss of species. However, it is not an ideal measure and care must be taken with interpretation (see below).An "ecological community" means an assemblage of native species that inhabits a particular area.

Current monitoring status

This indicator is monitored in all jurisdictions.

Development & interpretation issues

The number of species presumed extinct, endangered or vulnerable may increase either because more species are, in fact, at risk or because of a better understanding of species that were already at-risk. For this reason, the number of extinct, endangered and vulnerable species should be reported by major group together with the number of known and fully described species for each major group. The indicator can be interpreted most confidently if the number of known and fully described species for a major group remains unchanged. More careful analysis is required if the number of known species and the number of endangered species both increase. Methodology is established for identifying threatened species. This would be the first stage of implementing this indicator.

There is an emerging trend to monitor threatened communities, but at this stage the practice is not well enough established. Methodology for monitoring threatened communities requires development.This would be the second stage of implementing this indicator.

[Saunders et al: *BD 10.7 & 11.2; Ward* et al: *E+S 1.1]*

(ANZECC: BD 7) EXTENT AND CONDITION OF NATIVE VEGETATION [CONDITION]

The area and condition of native vegetation by type. In the absence of other measures, vegetation assemblages are used as surrogates for ecological communities and ecosystem diversity.

Why is this indicator important?

Ecosystem diversity may be correlated with the extent and condition of native vegetation types within them. Different vegetation types are the products of different ecological and environmental conditions and, therefore, could reflect different habitats and components of ecosystems e.g. species composition and amount of available habitat.

Why was this indicator selected?

The extent and condition of native vegetation, by type, is the best available surrogate for the condition of terrestrial ecosystem diversity at this time.

Current monitoring status

Some data to support this indicator are available in all jurisdictions. The intensity of monitoring varies. A number of initiatives – including the National Land and Water Resources Audit and the ANZECC National Framework for Management and Monitoring of Australia's Native Vegetation – are expected to improve the availability of data in the short to medium term.

Development & interpretation issues

Australia is currently working toward an agreed, hierarchical vegetation classification through the National Vegetation Information System (NVIS) project, with an agreed methodology available in the year 2000.

Methodology exists for identifying the extent of native vegetation types. This would be the first stage of implementing this indicator.

Far less equivalent data are available for marine ecosystem diversity, especially away from coastal settlements. Methodology for assessing condition requires further development.

[Saunders et al: *BD 11.1, 11.2 & 11.2]*

(ANZECC: BD 8) EXTENT AND CONDITION OF AQUATIC HABITATS [CONDITION]

The area and condition of marine, coastal, estuarine and freshwater habitats, by type. Marine and estuarine habitat types include algal beds, beaches and dunes, coral reefs, intertidal reefs, intertidal sand/mudflats, mangroves, saltmarshes, seagrass, and seamounts. Freshwater habitats include riverine areas and wetlands.

Why is this indicator important?	Different habitat types reflect different ecological and environmental conditions and, therefore, different components of biological diversity.
Why was this indicator selected?	The extent and condition of marine, coastal, estuarine and freshwater habitats, by type, is the best available surrogate for the condition of aquatic ecosystem diversity.
Current monitoring status	Mapping of marine, coastal, estuarine and freshwater habitats is patchy. Some data are available for most aquatic habitat types. Some large marine areas are poorly known.
Development & interpretation issues	This indicator is the aquatic analogue of "extent and condition" of native vegetation. This would be the first stage of implementing this indicator. Methodology for identifying condition requires further development. There are comparatively few data available on the extent and condition of marine, coastal, estuarine and freshwater habitats across Australia. Furthermore, currently available data are not nationally consistent in term of scale and classification. The NVIS may address these types of data gaps as part of stage two of its development. This research represents the second stage in implementing this indicator.

[Ward et al: *E+S 2.1-2.9, 3.1, 3.3-3.10, 3.12 -3.14 & 3.16; Saunders* et al: *BD 11.1, 11.2 & 13.1]*

(ANZECC: BD 9) **POPULATIONS OF SELECTED SPECIES** **[CONDITION]**

Estimated populations of selected species, including declining species, are an important measure for assessing the conservation status of species. They are also potential surrogates for assessing changes in genetic diversity.

Why is this indicator important?	It is important that a set of core environmental indicators include some measure of genetic diversity.
Why was this indicator selected?	Population changes are the best indirect measure currently available for assessing conservation actions and identifying potential trends in genetic diversity.
Current monitoring status	The monitoring status of this indicator cannot be properly assessed until target species are selected. Relevant data are probably available in most jurisdictions.
Development & interpretation issues	It is important to select target taxa that may be indicative of general trends. While moderate falls may not be significant, major declines in population probably indicate a concomitant decrease in genetic diversity for certain species. Selecting target taxa for this part of the indicator is quite a difficult challenge, and different species will probably be appropriate in each State and Territory. At present, there are no practical direct measures of genetic diversity (with the exception of a few taxa) and there exist difficulties in interpreting the results of such measures.

[Saunders et al: *BD 10.9 & 10.10 (see also 10.7), Ward* et al: *E+S 1.1, 1.2 & 3.6]*

ISSUE: Biodiversity Conservation and Management

(ANZECC: BD 10) **TERRESTRIAL PROTECTED AREAS** **[RESPONSE]**

Area by vegetation type in protected area categories as defined by IUCN, in hectares and as a percentage of the pre-1750 area, by IBRA region.

Why is this indicator important?	One of the objectives of the *National Strategy for the Conservation of Australia's Biological Diversity* is to "establish and manage a comprehensive, adequate and representative system of protected areas covering Australia's biological diversity". Protected areas are necessary, but alone are not sufficient, for sustaining biological diversity.
Why was this indicator selected?	Knowing how much of each vegetation type is in a protected area will help evaluate whether protected areas embrace the full range of habitats.
Current monitoring status	This indicator is monitored in most jurisdictions, and relevant data are available in all. There are variations in how finely vegetation types can be classified and also mapped at fine scales.
Development & interpretation issues	Refinements in vegetation classifications and mapping will enhance the value of this indicator. Methodology is established for IUCN classified areas. Information is becoming available. This would be the first stage of implementing this indicator. Methodology needs development for reserved land outside IUCN classifications which are important for conservation (e.g. off-reserve conservation on private land, and land under covenants or under CAR processes). This would be the second stage of implementing this indicator.

[Saunders et al: *BD 13.1]*

(ANZECC: BD 11) **MARINE AND ESTUARINE PROTECTED AREAS** **[RESPONSE]**

The number, extent and classification of marine and estuarine protected areas (classification based on IUCN World Conservation Union criteria). Also, area as a percentage of each IMCRA region.

Why is this indicator important?	One of the objectives of the *National Strategy for the Conservation of Australia's Biological Diversity* is to "establish and manage a comprehensive, adequate and representative system of protected areas covering Australia's biological diversity". Protected areas are necessary, but alone are not sufficient, for sustaining biological diversity.
Why was this indicator selected?	Knowing how many marine and estuarine areas are protected, and how much of each region is covered by protected areas, will help evaluate whether marine and estuarine biodiversity is adequately served by protected areas.
Current monitoring status	This indicator is currently monitored in all relevant jurisdictions.
Development & interpretation issues	Methodology is being established, although classification of reserve types needs some development. This would be the first stage of implementing this indicator. Methodology needs development for marine and estuarine areas, which have some form of protective status, but which are outside IUCN classified protected areas. This would be the second stage of implementing this indicator.

[Ward et al: *E+S 7.12 and Saunders* et al: *BD 13.1]*

(ANZECC: BD 12) **RECOVERY PLANS** **[RESPONSE]**

Recovery plans for threatened species and ecological communities as required under legislation.

Why is this indicator important?

Recovery plans for threatened species and communities are a significant element of societal response to the decline in species diversity.

Why was this indicator selected?

It is standard practice for recovery plans to be prepared for threatened species and communities; in many jurisdictions preparation of such plans is a legislative requirement, e.g. the *Environment Protection and Biodiversity Conservation Act 1999* (C'lth). The number of recovery plans alone is inadequate as an indicator of the efforts being made, and it is also necessary to know how many of these plans are funded for which taxa.

Current monitoring status

This indicator is monitored in all jurisdictions.

Development & interpretation issues

Interpretation of this indicator involves analysis of:

- Number of species or ecological communities listed under legislation for which recovery plans are required
- Number of species or ecological communities for which recovery plans have been developed
- Number of recovery plans being implemented.

All jurisdictions evaluate the success of recovery plans. Methodology is established.

[Saunders et al: *BD 15.1, BD6, BD9. BD10]*

(ANZECC: BD 13) **AREA REVEGETATED** **[RESPONSE]**

The area revegetated by species or genus, in hectares per annum, disaggregated into areas revegetated using local vegetation or other vegetation, and the purpose of the revegetation.

Why is this indicator important?

Revegetation is a significant societal response to processes threatening biodiversity. Native vegetation clearing is a major threat to biological diversity. While revegetated areas do not have the same environmental benefits as uncleared land, they restore many ecological values.

Why was this indicator selected?

This indicator is a direct measure of societal response.

Current monitoring status

Some data are available in most jurisdictions through the NHT and the ABS's agricultural survey and census.

Development & interpretation issues

For biodiversity purposes, the critical point for interpreting this indicator is that land must be revegetated with indigenous vegetation (that is, similar or identical to the original native vegetation). The method used is less significant. For some land it may be necessary to revegetate with non-local vegetation to restore soil function. Where this is a prelude to growing local vegetation, the revegetation efforts will be included at a later time. Revegetation can have other environmental benefits that are not directly related to biodiversity (e.g. improving hydrology). For these purposes the total area revegetated may be most important.

This indicator is directly relevant to the enhanced greenhouse effect issue.

Methodology requires further refinement on categories of purpose.

[Saunders et al: *BD 18.2]*

LAND INDICATORS

The land, and the way we manage it, affects the whole environment. Nutrients, chemicals, and particles washed from the land into rivers and estuaries, affect aquatic, estuarine and marine systems. The quality of the soil, and the vegetation it supports, are critical for both biological diversity and primary production.

Many issues relevant to land are covered by the core indicators for biodiversity and inland waters.

The core indicators for land are grouped under five main issues: land use and management, erosion, salinisation, acidification, and contamination.

Land use and management affects every aspect of the land environment. One indicator, namely change in land use, is presented. However it was not possible to specify a general response indicator which reported on the area of land under best practice management, which would have been relevant to all issues covered in this theme.

Erosion is an important issue for which it has been difficult to develop satisfactory indicators. Two indicators are presented: one pressure indicator (potential for erosion) and one condition indicator (wind erosion from high wind events). At present the methodology is not well developed enough to incorporate water erosion. The inland waters indicator “extent of deep-rooted vegetation” is also relevant here because it relates to changes in catchment hydrology. This set would ideally include indicators for the rate and extent of sheet, rill, and gully erosion, but it has not been possible to identify any that are satisfactory.

Three indicators, all of condition, are presented for salinisation and acidification. One of these, “area of rising watertables”, indicates areas at risk of salinisation or waterlogging. The others relate to the extent of dryland salinity and acidification.

Only one indicator related to land contamination could be developed at present; ie. exceedences of Maximum Residue Levels in food and produce. Other potential related indicators include: status of highly contaminated sites, concentration of biocides in the environment and volume of biocides sold.

ISSUE: Land use and management

(ANZECC: L 1) CHANGES IN LAND USE [PRESSURE/RESPONSE]

Area of each land-use, described under a standard classification.

Why is this indicator important?	Different land-uses are a major reason for differences in environmental condition. Land management practices associated with different uses have varying effects on the ecological functions, attributes and integrity of the land. Changes in land use are expected to continue.
Why was this indicator selected?	This indicator is a direct measure of the pressure.
Current monitoring status	Although there is some monitoring in all jurisdictions, Australia lacks a satisfactory national land use map. The National Land and Water Resources Audit (NLWRA) is expected to correct this.
Development & interpretation issues	A standard classification of land uses will be developed as part of the National Land and Water Resources Audit, with input from appropriate organisations (AUSLIG, ABS, Standards Australia, etc), and from this process.
Current land use pattern is a condition.	The importance of this indicator is in identifying the trends over time. Land use is different to land tenure, although tenure can significantly affect land management practices. Variations in management practices within the same land use category must be considered when interpreting this indicator. However, practice within a land use category (such as agriculture) will generally vary less than practices between land use categories (such as agriculture and pastoralism). A similar measure developed by the NCPISA will feed into this indicator. Methodology is currently being developed by the NLWRA. *[Hamblin: L 2.3]*

ISSUE: Erosion

(ANZECC: L 2) **POTENTIAL FOR EROSION** **[PRESSURE]**

The area of soil that is bare or lacks adequate vegetation cover to prevent accelerated wind or water erosion, classified by land use type, soil type, climate, and slope of land.

Why is this indicator important?

Erosion is a natural process that is accelerated by human activities. The slow rate of soil formation means that soil is effectively a non-renewable resource, and accelerated soil loss is a concern in many parts of Australia. Increased rates of erosion can have a negative effect on water quality in streams and rivers.

Why was this indicator selected?

Estimating rates of erosion is difficult, and requires more data than are currently available on a national scale (although estimates are possible in some small, well-studied regions). The approach adopted here is to monitor changes in vegetation cover. Vegetation cover strongly influences rates of erosion and changes in cover are strongly influenced by human activities.

The risk of erosion is linked to a range of factors, such as soil type and the slope of the land. For all soil types, the risk of erosion is greatly increased if vegetation cover falls below a threshold that depends upon land characteristics.

This indicator satisfies all selection criteria except being readily interpretable. The indicator can be interpreted (see below) with some effort, and is included here on the basis of the importance of the issue and the lack of other, more suitable indicators.

Current monitoring status

All jurisdictions hold some data on soil type, slope and vegetation cover. These data have not yet been combined in the type of analysis suggested here.

Development & interpretation issues

The area of bare soil or inadequate vegetation cover must be assessed against soil type, climate and the slope of the land, since these factors strongly influence the risk of erosion. A useful analytical tool is to compare lands with similar (preferably identical) climate, slope, and soil type but different uses. Such studies will help distinguish anthropogenic from non-anthropogenic effects. The set of soil reference sites proposed by ACLEP will also help interpret this indicator. This indicator is a pressure to the extent that changes in potential for erosion are due to human activities.

Non-human factors are also important.

Methodology is currently being developed.

[Hamblin:L 1.1A-1.3]

(ANZECC: L 3) **WIND EROSION FROM HIGH WIND EVENTS** **[CONDITION]**

Changes in the frequency of dust storms relative to high wind events.

Why is this indicator important?	Wind erosion is one of the main causes of soil loss in regions with annual rainfall below 600 mm. Dust from high wind events can also degrade the quality of the air for people downwind from eroding sites. Dust deposition can also increase turbidity in waterbodies.
Why was this indicator selected?	Work on the NCPISA has established a correlation between meteorological records of visibility and dust flux and loss of topsoil through high wind events. This technique can be used to estimate topsoil loss in arid and semi-arid regions. This indicator satisfies all selection criteria except ease of interpretation. A clear meaning can be assigned to this indicator, but expert interpretation using appropriate models is necessary.
Current monitoring status	This indicator is being compiled by the NCPISA (Dust Storm Index). The meteorological observations upon which this indicator depends are currently being made, and historical records are also available.
Development & interpretation issues	The model used to derive estimates of top soil loss is still being refined as is the future inclusion of water erosion as an indicator.
	Established NCPISA methodology.

[Hamblin:L 1.6]

ISSUE: Salinity

(ANZECC: L 4) **AREA OF RISING WATERTABLES** **[CONDITION]**

Area underlain by shallow watertables, and areas where watertables are rising.

Why is this indicator important?	Rising, shallow watertables are a major cause of waterlogging and salinisation. Both of these, particularly salinisation, are major problems in many parts of Australia.
Why was this indicator selected?	This indicator is a direct measure of the condition.
Current monitoring status	Some data are available in all jurisdictions.
Development & interpretation issues	None.
	Methodology is developed.

[Fairweather & Napier:IW 1.1]

(ANZECC: L 5) **AREA AFFECTED BY SALINITY** **[CONDITION]**

The area of land that is reported as having saline soils within the top metre, in regions of Australia with greater than 250 mm annual rainfall. This indicator covers areas affected by dryland and irrigation salinity.

Why is this indicator important?

Because Australian soils are old, much weathered and developed in climates where salts tend to accumulate, naturally saline soils occur widely. The distribution of saline soils has been increased by land management practices (such as irrigation and changes to vegetation cover) over the past two hundred years, particularly in higher rainfall environments (greater than 250 mm rainfall). While the increasing extent of soil salinity affects agricultural productivity directly, it also has the potential to affect other ecosystem functions, such as soil invertebrate numbers and nutrient cycling, and survival and reproduction of non-adapted native flora. It is important that we know which catchments and which agricultural environments are most affected.

Why was this indicator selected?

This indicator is a direct measure of the condition.

Current monitoring status

There are active programs to monitor salinity in all relevant jurisdictions. The National Land and Water Resources Audit is expected to complete a major study of dryland salinity.

Development & interpretation issues

Increases in the area of salinity measured by this indicator may simply be the result of additional survey activity. It is therefore important to distinguish increases in the area measured that are due to the expansion of already identified areas of salinity from those that result from the identification of previously unrecognised areas. The distinction also needs to be made between primary (ie. Naturally occurring saline conditions, eg. salt lakes) and secondary types of salinity (ie. Anthropogenic). Further, there may be a significant time lag between the onset of salinity and the practices that cause it, and in some cases these practices may already have ceased. Similarly, the causes of salinisation may be spatially separated from the effects.

Methodology is developed.

[Hamblin: L 3.3 (see also 5.3)]

ISSUE: Acidity

(ANZECC: L 6) AREA AFFECTED BY ACIDITY [CONDITION]

The area of land with soils that are reported as having acidity within the top metre, in regions of Australia with greater than 250 mm annual rainfall.

Why is this indicator important?	Australian soils are old and naturally acidic.The distribution of acidic soils has been increased by agricultural practices over the past two hundred years, particularly in higher rainfall environments (greater than 250 mm rainfall). Soil acidity is increased when pH is lowered; a common result of agricultural practices. Increasing the extent of soil acidity directly affects agricultural productivity and has the potential to affect other ecosystem functions. In particular, this may involve the mobilisation of abnormal amounts of heavy metals and other trace elements into water bodies and subsoils, where they can have harmful effects on biota. It is important that we know which catchments and which agricultural environments are most affected.
Why was this indicator selected?	This indicator is a direct measure of the condition.
Current monitoring status	Some data are available in all jurisdictions.
Development & interpretation issues	At present, the various techniques for measuring soil acidity are applied patchily across Australia, although some systematic studies that could provide useful baselines are available, including work by the NCPISA.

[Hamblin: L 3.3]

ISSUE: Contamination

(ANZECC: L 7) **EXCEEDENCES OF THE MAXIMUM RESIDUE LEVELS IN FOOD AND PRODUCE** **[CONDITION]**

The number of samples of rural produce and food which exceed the Maximum Residue Levels (MRL) for contaminants are a surrogate for land/water contamination.

Why is this indicator important?	There is public concern and interest over the use of chemicals in agriculture (herbicides, insecticides, fungicides, anthelmintics, carcinogens, heavy metals and antibiotics) and their residues in foods and other produce. This indicator also applies to foods taken from the freshwater and marine environments. Data on residue levels will also provide some information on the movement of these contaminants through the food chain.
Why was this indicator selected?	This indicator is a direct measure of the condition.
Current monitoring status	There are programs to monitor residues in all relevant jurisdictions. National monitoring is conducted by the National Residue Survey and the National Basket Survey. Some states also have monitoring schemes.
Development & interpretation issues	As the MRLs used are designed to protect human health they are of limited value in assessing the effects of these residues on the environment. However, they do provide some information on the expected uptake by different types of plants and animals. Methodology is developed.

[Hamblin: L 6.7 + Ward: ES 4.4 + Fairweather: IW 3.4]

INLAND WATERS INDICATORS

Inland waters are defined as all underground and surface waters not associated with the sea. The suggested core environmental indicators for inland waters are grouped under three issues:
(i) groundwater;

(ii) surface water; and

(iii) aquatic habitats.

Ideally, the set of core indicators would include an indicator of the condition of stream and river hydrology (including channel condition). However, it was not possible to identify a simple, measurable indicator.It should be possible to infer useful information about stream and river hydrology from the pressure indicator "extent of deep-rooted vegetation cover by catchment" and the response indicator "environmental flow objectives".

The indicators for aquatic habitats are closely related to the core indicators for biological diversity.

ISSUE: Groundwater

(ANZECC: IW 1) **GROUNDWATER EXTRACTION VERSUS AVAILABILITY** **[CONDITION]**

Aquifers with falling water levels or bore pressures.

Why is this indicator important?	Shallow aquifers, or artesian bores are being "mined" in parts of Australia. That is, groundwaters are being extracted faster than the rate of natural recharge. Persistently falling water levels or bore pressures indicate that extraction exceeds recharge. This is an unsustainable practice in the long term, and can stress natural and modified ecosystems that depend on groundwaters for their survival.
Why was this indicator selected?	Aquifers are fundamental to rural towns and for agriculture; more than half of the continent totally relies on them for all uses except drinking water.
Current monitoring status	This indicator is currently monitored, at least partially, in most jurisdictions.
Development & interpretation issues	Where possible, the rate at which water levels (or bore pressures) are falling should also be reported. Methodology is established.

[Fairweather & Napier: IW 1.1]

(ANZECC: IW 2)	EXCEEDENCES OF GROUNDWATER QUALITY GUIDELINES	[CONDITION]

Salinity and nitrate levels in groundwater.

Why is this indicator important?

Nationally, salinity is the major water quality limitation on the environmental values (including potential beneficial uses) of groundwater. It is influenced by human action such as accessions of irrigation water, disposal of waste waters, and seawater intrusion in response to excessive extraction from coastally linked aquifers. It is generally only necessary to monitor nitrate levels where health issues are important. Rising nitrate levels suggests that the aquifer is being polluted from point or diffuse sources.

Why was this indicator selected?

The Guidelines for Groundwater Protection (ARMCANZ/ANZECC, 1995) are used to indicate significant levels of change for a range of environmental values, including human health, recreation, irrigation, stock watering, and protection of aquatic ecosystems.

This indicator is a direct measure of the condition.

Current monitoring status

Some data are available in all jurisdictions.

Development & interpretation issues

Where background salinities are moderate to high, salinity is a less useful measure of anthropogenic pollution, although it may still limit the possible beneficial uses of groundwater. Data collected from shallow and deeper levels should be reported separately.

Methodology is established.

[Fairweather & Napier: IW 1.2, 3.1 & 3.3]

ISSUE: Surface water

(ANZECC: IW 3) **EXTENT OF DEEP-ROOTED VEGETATION COVER BY CATCHMENT** **[PRESSURE]**

The proportion of each catchment under deep-rooted vegetation.

Why is this indicator important?	Changes in the type of vegetation cover in a catchment have a major effect on important hydrological processes. Erosion potential and catchment hydrology are also affected.
Why was this indicator selected?	Deep-rooted vegetation prevents excessive discharge of salt laden waters to lower parts of the landscapes, ground and surface waters. The form of vegetation is less significant, with deep-rooted grasses, herbs and shrubs being as effective as trees.
Current monitoring status	Some data are available in all jurisdictions. This indicator can be derived from the data supporting the biodiversity indicator "extent and condition of native vegetation cover" by superimposing catchment boundaries on the vegetation maps.
Development & interpretation issues	The area of bare soil or sealed surfaces should also be taken into account in interpreting this indicator. This indicator is a pressure to the extent that human activities have contributed to changes in vegetation cover. Methodology is under development.

[Hamblin: L 3.1 (see also 2.5)]

(ANZECC: IW 4) **SURFACE WATER EXTRACTION VERSUS AVAILABILITY** **[PRESSURE]**

The ratio of water use compared to catchment yield. Water extraction to be disaggregated by use and source.

Why is this indicator important?

Allocation of water is a major issue in Australia: the driest inhabited continent, and one with highly variable rainfall. The need to allocate water to the environment (to maintain river health and environmental flows) as well as to extractive uses is now widely recognised.

Why was this indicator selected?

Knowing how much water is extracted and the uses to which it is put is essential for understanding the allocation of this important resource. Water extraction can only be properly evaluated when the availability of water is also taken into account.

Current monitoring status

Some data relevant to this indicator are available in all jurisdictions.

Development & interpretation issues

This indicator would ideally measure the ratio of water required to water available. Water required would include an estimate of the water needed by the environment in addition to water extracted. However, understanding of environmental water requirements is not sufficiently advanced to construct such a measure. This may change in the future.

Methodology is being refined.

[Fairweather & Napier IW 4.7, 4.2, 4.1, 1.3, 1.4 & 1.5]

(ANZECC: IW 5) **ENVIRONMENTAL FLOWS OBJECTIVES** **[RESPONSE]**

The number of waterways for which environmental flow provisions have been established, and the number where provisions are being met.

Why is this indicator important?

Environmental flows aim to ensure a supply of water adequate to maintain ecosystem function in inland water systems. Since the 1994 COAG decision to ensure that the environment is considered a valid user of water, jurisdictions have begun to consider objectives for environmental flows. This is a significant societal response to a perceived environmental issue.

Why was this indicator selected?

Work to establish environmental flow provisions only began recently and it is therefore important to monitor progress. Where environmental flow provisions have been established, it is important to monitor whether they are being met.

Current monitoring status

Some data are available in most jurisdictions. The availability of data will improve in all jurisdictions as COAG water reform guidelines are implemented.

Development & interpretation issues

In future it will be necessary to develop indicators of whether environmental flow provisions are adequate.

Methodology is established.

[Fairweather & Napier: IW 4.4]

(ANZECC: IW 6) **DISCHARGES FROM POINT SOURCES** **[PRESSURE]**

The location and number of point source discharges into inland waters, including the type and load of materials discharged.

Why is this indicator important?	Point sources discharge a variety of loads and pollutants to inland water systems. These point sources include sewage outfalls, urban stormwater drains, and industrial outfalls.
Why was this indicator selected?	This indicator is a direct measure of the pressure.
Current monitoring status	Data are available in all jurisdictions. The availability of data will improve as reporting through the National Pollutant Inventory (NPI) is implemented.
Development & interpretation issues	Methodology exists for identifying point source discharges and loads. This would be the first stage of implementing this indicator. Methodology for identifying loads from non-point sources is under development by the NPI. Thresholds for including non-point sources will be consistent with those set for the NPI. This would be the second stage for implementing this indicator.

[Fairweather & Napier: IW 3.6 (see also 3.1)]

(ANZECC: IW 7) **SURFACE WATER SALINITY** **[CONDITION]**

Salinity levels in surface waters.

Why is this indicator important?	Concern has been raised about the increased salinity of many of Australia's rivers. As a continent with many ancient seabeds – formed during periods of marine inundation – beneath it, Australia is prone to salinisation even without the anthropogenic influence of irrigation and tree clearance. Continued attention is needed to assess the extent of the problem and the effectiveness of management practices for salt reduction.
Why was this indicator selected?	This indicator is a direct measure of the condition. A corresponding indicator is included in the NCPISA, and both indicators will draw upon the same data.
Current monitoring status	Some data are available in all jurisdictions.
Development & interpretation issues	Trends in surface water salinity are of most interest. Methodology is established by NCPISA and is being reviewed by the NLWRA.

[Fairweather & Napier: IW 3.13 (see also 1.2)]

(ANZECC: IW 8)	EXCEEDENCES OF SURFACE WATER QUALITY GUIDELINES	[CONDITION]

Percentage exceedences of ANZECC water quality guidelines for a suite of microbiological, bacterial and chemical water quality parameters relating to:

- **protection of aquatic ecosystems,**
- **primary contact recreation,**
- **irrigation, and**
- **stock watering.**

(Exceedences to be reported separately for each use.)

Why is this indicator important?	Water has many environmental values, including recreation, irrigation, stock watering, and the protection of aquatic ecosystems. The maintenance of these values is a critical environmental issue.
Why was this indicator selected?	Since there are regional variations in the environmental values of water and baseline environmental conditions, this indicator allows for variation in the parameters measured and frequency of measurement for each water body, in accordance with the National Water Quality Management Strategy. Water Quality Guidelines (ANZECC, 1992, currently being revised – draft 1999) are used to indicate significant levels of change for a range of environmental values, including human health, recreation, irrigation, stock watering, and protection of aquatic ecosystems.
Current monitoring status	Water quality is widely monitored in all jurisdictions. It is expected that the revised ANZECC water quality guidelines will be applied incrementally over the next few years.
Development & interpretation issues	The ANZECC water quality guidelines have not yet been applied to all waterbodies. Interim application should follow the joint Environment Australia and NLWRA methodology/rules for reporting on exceedences. Methodology is established.

[Fairweather & Napier: IW 3.1]

(ANZECC: IW 9) **FRESHWATER ALGAL BLOOMS** **[CONDITION]**

Incidence of freshwater algal blooms.

Why is this indicator important?

Algal blooms are a potential surrogate indicator of eutrophication or high nutrient load. High nutrient concentrations in surface waters have been linked to algal blooms and poor water quality.

Why was this indicator selected?

Measuring nutrient concentrations alone is inadequate for understanding nutrient conditions in Australian waters. A focus on nutrient loads (amount per unit time) will identify key areas of inputs of degraded water from both rural and urban sources, but loads are expensive to monitor.

If data on nutrient concentrations and loads are not available, then the most appropriate surrogates are either chlorophyll *a* concentrations or algal bloom events. Chlorophyll *a* concentration is a more direct indicator of algal biomass, while algal bloom events are indicative of algal species outbreaks which directly threaten biodiversity, water quality and human health. (Note: Chlorophyll *a*, nitrogen and phosphorus are among the water quality parameters covered by ANZECC IW8).

Current monitoring status

Regular monitoring is undertaken for some reservoirs in most jurisdictions. There are various State and Territory committees, which coordinate the implementation of strategies for the control of algal blooms.

Development & interpretation issues

Methodologies are developed, and a number of jurisdictions have documented protocols for interpreting the status of algal blooms. The formulation of an agreed national protocol is being investigated.

The effectiveness of various strategies, such as nutrient control or flow management plans, might be gauged from the number of algal blooms effectively controlled.

[Fairweather & Napier: IW 3.2 & 3.3]

(ANZECC: IW 10) WASTE WATER TREATMENT (INLAND WATERS) [RESPONSE]

The number of waste water treatment plants, together with the volume of waste water released to inland waters, disaggregated according to the level of treatment or filtration used.

Why is this indicator important?	Treatment of waste water to primary, secondary or tertiary levels exerts different (progressively lessening) pressure on the receiving water environment. Treatment of waste water is a significant societal response to water quality concerns.
Why was this indicator selected?	The volume of water released is a less precise measure than the actual quantities of pollutants (pathogens, nutrients etc); it is, however, much more readily measured. Actual quantities of pollutants should be reported where available.
Current monitoring status	This indicator is monitored in all jurisdictions, at least to the level of number of waste water treatment plants. Data on emissions from waste water treatment plants will be reported through the National Pollutant Inventory. The first NPI reporting year was 1998/99, data will be available from January 2000.
Development & interpretation issues	Classification of treatment levels varies. Adopted established NPI methodology.

[Fairweather & Napier: IW 2.3]

(ANZECC: IW 11) **WASTE WATER RE-USE (INLAND WATERS)** **[RESPONSE]**

Waste water re-use, expressed as a percentage of total waste water discharged

Why is this indicator important?

Waste water re-use can reduce the need for abstractions, thereby helping to conserve Australia's water resources. The re-use of water is also important in diverting nutrients and other pollutants that may otherwise enter waterways.

Why was this indicator selected?

Waste water re-use is an important response both to water quality and water quantity issues. The re-use indicator should be considered in association with the water use to catchment yield indicator in inland waters.

Current monitoring status

Local government, water utilities, and waste water authorities have information on re-use. Where EPA licences are issued to water boards to allow re-use, there are reporting requirements included in the licence that will provide information on re-use volumes. The Water Account Project being undertaken by the ABS has sought data on the volume of treated effluent transferred to other users for reuse.

Development & interpretation issues

A second stage development of this indicator would report on the per cent of waste water re-use by type of application. The following categories are proposed:

- Effluent irrigation onto agricultural land, forests, golf courses, parks and playing fields
- Non-potable domestic reuse (e.g. for garden watering)
- Non-potable commercial and industrial reuse

Direct and indirect potable water supplies.

Note: This indicator does not include stormwater.

[Developed by ANZECC SoER Task Force]

ISSUE: Aquatic habitats

(ANZECC: IW 12) **VEGETATED STREAMLENGTH** **[PRESSURE]**

The percentage of total streamlength with riparian vegetation per drainage division. The width of the riparian zone and the quality of the riparian vegetation should also be reported.

Why is this indicator important?	Riparian vegetation protects waterbodies from pollutants travelling overland in runoff, guards against excessive erosion, and is an important energy source (through litterfall) for the aquatic ecosystems. Removing riparian vegetation can degrade waterbodies.
Why was this indicator selected?	The pressure on inland waters comes from removal of riparian vegetation (ie the complement of this indicator). However, it is more meaningful to report on the remaining vegetation than on the vegetation that has been removed or degraded.
Current monitoring status	Some data are available in most jurisdictions.
Development & interpretation issues	Assessing the quality of riparian vegetation is more difficult than monitoring the vegetated stream length. Techniques are available, but an agreed method has yet to be developed. Simply reporting the length of vegetated stream will still provide useful information. Methodology is developed for the initial stage. Methodology for assessing width and quality of riparian zone will have to be refined for the second stage.

[Fairweather & Napier: IW 5.1]

(ANZECC: IW 13) **RIVER HEALTH (AUSRIVAS)** **[CONDITION]**

Assemblages of macroinvertebrates in rivers as assessed by AusRivAs (Australian River Assessment Scheme) sampling protocols and computer models.

Why is this indicator important?

"River health" is a concept that goes beyond suitability of water for particular uses and integrates a range of ecosystem values and functions. It complements more traditional assessments of water quality by introducing an ecosystem perspective.

Why was this indicator selected?

Macroinvertebrate assemblages integrate many aspects of the 'health' of streams and rivers. The AusRivAS sampling protocols were developed as part of the National River Health Program's Australia-wide Assessment of River Health, which is funded through the Natural Heritage Trust. Since 1994, more than 1500 reference sites across Australia have been sampled to build predictive models to interpret field sampling results.

Current monitoring status

Between 1994 and 1999, AusRivAS has been used to undertake the Australia-wide Assessment of River Health, with approximately 6000 sites having been sampled and assessed. The Urban River Health Assessment sub-program, funded through the Living Cities initiative, will also utilise AusRivAS for urban river health assessment during 2000–2002. The australia-wide Assessment of River Health does not cover every single stream and river in Australia.

Development & interpretation issues

This indicator is being developed as part of the National River Health Program.

Adopted established AusRivAS methodology. AusRivAS is currently being updated and refined. By the end of 2001 AusRivAS will include protocols for a suite of bio-indicators, including benthic macroinvertebrates, diatoms, physico-chemical assessment, benthic community metabolism and fish. The AusRivAS system is progressively being improved to provide updated models for all States and Territories, and additional protocols for urban and semi-arid/arid river health assessment.

[Fairweather & Napier: IW 6.1]

(ANZECC: IW 14) EXTENT AND CONDITION OF WETLANDS [CONDITION]

The extent and condition of wetlands in each drainage division.

Why is this indicator important?	Wetlands have an important ecological function and are essential to many species, such as waterbirds. The extent and distribution of wetlands is basic information for inventory and other managerial purposes. Draining and other land uses have reduced wetland area.
Why was this indicator selected?	This indicator is a direct measure of the condition.
Current monitoring status	Wetland directories covering most of Australia have been produced. However little information on condition exists.
Development & interpretation issues	Definitions of wetlands vary. Here they are defined as any land thought to be naturally wet, either permanently or intermittently (ie after heavy rains in the catchment). Wetlands of international importance should be listed as a separate category, and different types of wetland (e.g. permanent versus temporary) should be treated separately. Methodology exists for identifying the extent of wetlands. This would be the first stage of implementing this indicator. Methodology for identifying condition of wetlands requires development. This would be the second stage of implementing this indicator.

[Fairweather & Napier: IW 6.7]

(ANZECC: IW 15) **ESTIMATED FRESHWATER FISH STOCKS** **[CONDITION]**

Expert assessments of the status of freshwater fish and crustacean stocks.

Why is this indicator important?	Many native fish and crustacean species have suffered serious declines in abundance and diversity in most regions of Australia since European settlement. About one third of inland-water native fish have undergone major reductions in range. Continued pressures through habitat modification, introduced pests, pollution and harvesting continue to effect native fish species.
Why was this indicator selected?	This indicator is a direct measure of the condition.
Current monitoring status	A number of inland fisheries now use licences, regulations and strict guidelines protect dwindling stocks of fish (such as barramundi and Murray cod) and crustaceans (such as the Murray crayfish and marron). Stock assessments are carried out in some States.
Development & interpretation issues	Estimates for the size of reproducing population should be made for any exploited species. Methods for collecting these estimates will depend on what is known of species, life histories etc. Data should be collected from those involved in harvesting activities. Some recreational impacts, such as recreational fishing present a challenge, especially for fisheries without any licensing. This problem can be overcome by correctly structured surveys. The AUSRIVAS project is currently developing a protocol to include fish in its measures for water quality. Methodology is established. *[Developed by ANZECC SoER Task Force]*

ESTUARIES AND THE SEA INDICATORS

The suggested core environmental indicators for estuaries and the sea are grouped under three issues: marine habitat and biological resources; estuarine and marine water quality; and ecosystem processes. Note: this theme is now referred to as coasts and oceans for the 2001 Australian SoE Report.

There are strong links between the marine habitat and biological resources indicators and the biodiversity indicators, and the two sets should be considered together. Similarly, there are links between many of the inland waters and land indicators and the marine water quality indicators. Human populations and their activities on the land (particularly the coastal strip) and nutrient loads in rivers draining to the sea are an important human influence on marine and estuarine water quality.

Two broad-scale indicators that are relevant to important ecosystem-level processes in marine and estuarine ecosystems have been chosen. They are:

- sea level
- sea surface temperatures

These indicators also have an important role in interpreting trends that might be detected in the other indicators.

The lack of information on the marine environment, particularly physical and ecological processes, means that significant conceptual development work is needed to develop further marine indicators.

ISSUE: Marine habitat and biological resources

(ANZECC: E+S 1) **CHANGES IN COASTAL USE** **[PRESSURE]**

The length or area of the coast used for structures associated with activity.

Why is this indicator important?	The coast is heavily used for a variety of activities – including aquaculture, marinas, and navigation channels – that can affect fragile coastal ecosystems.
Why was this indicator selected?	The length or area of the coast physically changed for each activity is the best simple measure of its extent.
Current monitoring status	Some data are available in most jurisdictions.
Development & interpretation issues	An increase in the area used suggests increased pressure, but measures to reduce the environmental impacts (such as providing waste disposal facilities for marinas) should also be taken into account. This indicator complements the change in land use indicator. Methodology is developed.

[Ward et al: E+S 4.1, 7.6 & 7.7]

(ANZECC: E+S 2) DISTURBANCE OF MARINE HABITAT [PRESSURE]

Area of marine habitat subject to: (a) trawling, (b) anchorage sites, (c) dredging (including dredge spoil dump sites), (d) navigation channels, (e) exploration, and (f) mining.

Why is this indicator important? A number of human activities disturb marine habitats, with potentially damaging effects on benthic ecosystems.

Why was this indicator selected? The nature and severity of effects on marine habitats depends on the type of disturbing activity. A distinction is therefore made between different types of activity.

Current monitoring status Some data are available in all relevant jurisdictions.

Development & interpretation issues The impact of disturbing activities can depend on their frequency and whether the area has previously been disturbed. For example, continued trawling may prevent the recolonisation of the benthic species, both sedentary and mobile forms. Trawling in previously untrawled areas can have major effects on bottom flora and fauna in the trawl path.

Methodology is developed.

[Ward et al: *E+S 4.5, 4.6, 5.1, 5.2, 7.6, 7.7 & 7.14]*

(ANZECC: E+S 3) TOTAL SEAFOOD CATCH [PRESSURE]

The total catch of fish (excluding aquaculture) disaggregated into: commercial fish catch (by species where possible), discarded catch, landed bycatch and estimated recreational and subsistence catch.

Why is this indicator important? The harvesting of fish, crustaceans and molluscs from the marine environment is a major human activity affecting marine biodiversity.

Why was this indicator selected? Total fish catch gives an estimate of the magnitude of pressure from harvesting biomass from the marine environment. While stock assessments are available for some major commercial fisheries, there are few other measures to provide clues to the health of other fish stocks.

Current monitoring status Reasonable data are available on commercial fish catch. Estimating recreational fish catch is more difficult but is underway in several jurisdictions. By-catch figures are being developed in some areas.

Development & interpretation issues Total fish catch is a gross indicator of pressure on fish stocks but does not indicate the health of those stocks. This indicator should be interpreted carefully. It may, for example, trigger a full scientific assessment of fish stocks thought to be under heavy pressure, but cannot on its own indicate the health of such stocks.

Methodology is developed, but interpretation is complex and needs further development.

[Ward et al: *E+S 4.3 & 4.5; Saunders* et al: *BD 8.3 & 8.4]*

(ANZECC: E+S 4) **ESTIMATED WILD FISH STOCKS** **[CONDITION]**

Expert assessments of the status of wild stocks of fish, crustaceans and molluscs.

Why is this indicator important?	Fish stocks are known to be subject to pressure, and it is widely agreed that the condition of these stocks should be regularly assessed.
Why was this indicator selected?	This indicator is an expert assessment of the status of major fish stocks. Assessments are largely based on fish catch, adjusted for commercial effort, and population dynamics of the species involved.
Current monitoring status	Fish stocks are estimated for many commercial fisheries. Few data are available for other fish stocks.
Development & interpretation issues	It would be beneficial, from the perspective of monitoring the environment, to extend the assessment of fish stocks to non-commercial fish (ie. discarded bycatch), although the expense may not be justified. Methodology is developed.

[Ward et al: *E+S 4.3]*

ISSUE: Estuarine and marine water quality

(ANZECC: E+S 5) **COASTAL DISCHARGES** **[PRESSURE]**

The location and number of point-source discharges into estuaries, lagoons, bays, and coastal waters, including the types and loads of materials discharged.

Why is this indicator important?	Point sources may discharge large loads of pollutants into coastal waters. These point sources include sewage outfalls, urban stormwater drains, and industrial outfalls.
Why was this indicator selected?	This indicator is a direct measure of the pressure.
Current monitoring status	Data are available in all jurisdictions. The availability of data will improve as reporting through the National Pollutant Inventory (NPI) is implemented.
Development & interpretation issues	None. Adopt established NPI methodology for point sources. This would be the first stage of implementing this indicator. Methodology for non-point sources is under development by the NPI. This would be the second stage of implementing this indicator.

[Ward et al: *E+S 7.5]*

(ANZECC: E+S 6) **MARITIME POLLUTION INCIDENTS** **[PRESSURE]**

Number of pollution incidents reported to the Australian Maritime Safety Authority.

Why is this indicator important?	Shipping accidents range from minor groundings to major, highly visible and often locally catastrophic ship-to-ship collisions or groundings. Repeated accidents may cause serious environmental problems, and even a single accident may have a major impact on a highly sensitive habitat or sensitive species. Losses of oil, cargo, and other materials from ships during routine operations can also affect the marine environment. Oil spills resulting from other sources such as pipe lines are also reported to AMSA and can be covered by this indicator.
Why was this indicator selected?	Most marine pollution incidents – and all major incidents – are reported to the Australian Maritime Safety Authority.
Current monitoring status	This indicator is monitored by the Australian Maritime Safety Authority.
Development & interpretation issues	It is desirable to distinguish between major and minor marine pollution incidents. The records kept by the Australian Maritime Safety Authority should make such distinctions possible. Minor pollution incidents may not be reported in some jurisdictions (but small chronic incidents may have major effects). Methodology is established.

[Ward et al: *E+S 7.15]*

(ANZECC: E+S 7)	EXCEEDENCES OF MARINE AND ESTUARINE WATER QUALITY GUIDELINES	[CONDITION]

Percentage exceedences of marine and estuarine water quality guidelines for a suite of microbiological and chemical water quality parameters relating to:

- **protection of aquatic ecosystems, and**
- **primary contact recreation.**

(Exceedences to be reported separately for each use.)

Why is this indicator important?	Water has many environmental values, including recreation and the protection of aquatic ecosystems. The maintenance of these values is a critical environmental issue.
Why was this indicator selected?	Since there are regional variations in the environmental values of water and baseline environmental conditions, this indicator allows for variation in the parameters measured and frequency of measurement for each water body. The Australian Water Quality Guidelines for Fresh and Marine Waters (ANZECC 1992, currently being revised – draft 1999) are expected to indicate significant levels of change for a range of environmental values, including human health, recreation and protection of aquatic ecosystems.
Current monitoring status	A range of water quality parameters are monitored in most jurisdictions. It is expected that the forthcoming NEPM will be applied incrementally over the next few years.
Development & interpretation issues	The ANZECC Water Quality Guidelines (draft 1999) and NEPM which are still under development.

[Fairweather & Napier: IW 3.1; Ward et al: *E+S 6.2, 6.3 & 6.4]*

(ANZECC: E+S 8) **BIO-ACCUMULATED POLLUTANTS** **[CONDITION]**

The levels of major contaminants in biological accumulators in the estuaries, lagoons, bays and continental shelfs of the mainland and offshore islands.

Why is this indicator important?	Chemical residues and industrial chemicals are found in estuaries and bays near the major urban and industrial agglomerations, and potentially near regions of intensive agriculture. When in their biologically active forms, these pollutants are potentially harmful to a range of species including humans, mainly through bioaccumulation effects in the food chain.
Why was this indicator selected?	Most marine and estuarine waters have relatively low concentrations of chemical residues, and measurements by traditional water chemistry techniques are time consuming, laborious and expensive. As natural bioaccumulaters, oysters, mussels and other taxa have been used to monitor the water column levels of many chemicals, and offer an early warning device to detect the spread of unpredicted residues into otherwise uncontaminated areas. Measurement of levels of contaminants in natural biological tissues is also a useful way to track long-term trends in levels of most contaminants in marine and estuarine systems.
Current monitoring status	Data are available in some jurisdictions.
Development & interpretation issues	None. Methodology is established.

[Ward et al: *E+S 6.2]*

ALGAL BLOOMS IN ESTUARINE AND MARINE ENVIRONMENTS (ANZECC E+S 9) **[PRESSURE/CONDITION]**

The frequency of algal blooms, and dominant species of algae responsible for them.

Why is this indicator important?

Algal blooms have major detrimental effects on estuarine and marine environments. They degrade recreational amenity and fisheries, can be toxic, affect natural ecosystems, and have major consequences for tourism.

Why was this indicator selected?

Measuring nutrient concentrations alone is inadequate for understanding nutrient conditions in Australian waters. A focus on nutrient loads (amount per unit time) will identify key areas of inputs to the estuarine and marine environment, but loads are expensive to monitor.

If data on nutrient concentrations and loads are not available, then the most appropriate surrogates are either chlorophyll *a* concentrations or algal bloom events. Chlorophyll *a* concentration is a more direct indicator of algal biomass, while algal bloom events are indicative of algal species outbreaks which can directly threaten biodiversity, water quality and human health. (Note: Chlorophyll a, nitrogen and phosphorus are among the water quality parameters covered by ANZECC E+S 7).

Current monitoring status

Algal blooms are monitored in some jurisdictions, however at present this is mostly on an ad hoc basis which makes comparison across jurisdictions difficult.

Development & interpretation issues

Methodologies are developed, and a number of jurisdictions have documented protocols for interpreting the status of algal blooms. The formulation of an agreed national protocol is being investigated.

Chlorophyll a concentrations exhibit natural spatial and temporal variability. Care must be taken to distinguish this natural variation from changes in long term nutrient and eutrophication status.

[Ward et al: *E+S 3.2, 3.17, 6.4, 7]*

(ANZECC: E+S 10) WASTE WATER TREATMENT (COASTAL WATERS) [RESPONSE]

The number of waste water treatment plants, together with the volume of waste water released to coastal and estuarine waters, disaggregated according to the level of treatment or filtration used.

Why is this indicator important?	Untreated water can cause disease or pollution. Treatment to primary, secondary or tertiary levels exerts different (progressively lessening) pressure on the receiving water environment. Treatment of waste water is a significant societal response to water quality concerns.
Why was this indicator selected?	The volume of water released is a less accurate measure than the actual quantities of pollutants (pathogens, nutrients etc). It is, however, much more readily measured. Actual quantities of pollutants should be reported where available.
Current monitoring status	This indicator is monitored in all jurisdictions, at least at the level of number of waste water treatment plants. Data on emissions from waste water treatment plants will be reported through the National Pollutant Inventory. The first NPI reporting year was 1998/99 and data is now available.
Development & interpretation issues	Classification of treatment levels varies. Adopt established NPI methodology.

[Fairweather & Napier: IW 2.3; Ward et al: *7.5; and Newton* et al. *2.5, 2.10, 2.12]*

(ANZECC: E+S 11) DISTURBANCE OF POTENTIAL ACID SULFATE SOILS [PRESSURE]

The area of potential acid sulfate soils disturbed by development resulting in acid drainage and impacts on aquatic organisms.

Why is this indicator important?	Australia has large areas of soils containing iron sulfides. These soils are found in coastal areas typically less than 5 m above sea level. Developments such as agriculture, urbanisation, resorts and marinas are often concentrated in these areas. Through drainage, earth moving or dredging, these normally waterlogged soils may be exposed to air, oxidising the iron sulfides. Sulfuric acid is produced when the soils are re-wetted. The acidic water draining from these soils damages or inhibits aquatic organisms and terrestrial plants.
Why was this indicator selected?	This indicator is a direct measure of the pressure.
Current monitoring status	Some jurisdictions have mapped the areas of potential acid sulfate soils. Monitoring, remediation and avoidance are carried out in various areas.
Development & interpretation issues	The methodology for testing and identifying potential acid sulfate soils is developed but their location and extent have not been fully mapped.

[Ward et al: *E+S 6.2]*

ISSUE: Global processes

(ANZECC: E+S 12) **SEA LEVEL** **[CONDITION]**

Long-term sea level at the Australian coast and at offshore islands.

Why is this indicator important?

Sea level is rising. The extent of the rise, and local variability in the rate of rise, are important issues in planning how to respond. Increasing sea levels may have important impacts on coastal habitats, particularly those such as algal beds and seagrasses that have depth-limited distributions related to light availability. However, intertidal assemblages on hard and soft substrates are also likely to be influenced by rising sea level as the area available for their habitat alters; this change will be related to local topography and human responses to sea level rise. Rising sea levels will also increase the risk to beaches and dunes from extreme climatic events, and increase risks to coastal roads, housing, ports etc. The way in which sea level interacts with climatic change is of critical importance.

Why was this indicator selected?

This broad-scale ecosystem-level process indicator provides a signal that climatic change is occurring.

Current monitoring status

The data on this indicator will be gathered by annual consultation with the National Tidal Facility in Adelaide to establish sea level changes at each gauge location. A baseline of data has been captured by the National Tidal Facility.

Development & interpretation issues

This indicator will track changes in the sea level at a range of fixed locations along the coastline. These data can be used to construct empirical models to explain (and predict) various patterns that may be observed in the data gathered on other indicators. For example, mean sea level at Fremantle is used to predict lobster recruitment onto coastal reefs, and subsequently into the Western Australian lobster fishery. Other useful models may be constructed in relation to coastal erosion, seagrass loss etc.

Adopt the established National Tidal Facility methodology.

[Ward et al: *E+S 8.1]*

(ANZECC: E+S 13) **SEA SURFACE TEMPERATURE** **[CONDITION]**

Variability of sea surface temperatures (SST) in all estuarine, coastal and offshore waters of Australia's Exclusive Economic Zone.

Why is this indicator important?	As climate changes, or becomes more variable, the patterns of ocean currents may also alter. The changes could include shifts in the dominant currents. As a result, seasonal patterns of sea surface temperature variability could change, affecting the spawning, recruitment, growth and distribution of both economically important species and others. SST is also a useful surrogate for general current patterns, particularly when combined with ocean colour (chlorophyll a).
Why was this indicator selected?	This broad-scale ecosystem-level process indicator provides a signal that climatic change is occurring.
Current monitoring status	The data on this indicator would be gathered by satellite remote sensing techniques. New satellite platforms will be able to supplement the existing ones to enhance the quality of available SST data. The data for this indicator are purchased and archived by the CSIRO Earth Observation Centre in Hobart.
Development & interpretation issues	This indicator will track broad-scale changes in SST. Its primary use will be to explore patterns in SST variability that may be related to patterns of variability in other indicators, particularly those describing the condition of habitats. Methodology is established.

[Ward et al: *E+S 8.2]*

HUMAN SETTLEMENTS

Human settlements are the environments in which most Australians live. Human settlements include cities, rural towns, and remote settlements.

Suggested core indicators for human settlements are grouped under six main issues: Energy, Water, Demographics, Transport, Waste, and Community Attitudes and Actions.

Stormwater and noise are recognised as important issues for which it has not yet been possible to develop condition indicators that satisfy the selection criteria.

Consumption patterns of individuals are also recognised as an important issue and have been addressed indirectly through links with 4 core indicators; HS 1 – Energy Use, HS 9 – Fuel consumption per transport output, HS 10 – Waste generation, and IW 4 – Water extraction.

Environmental health is an important issue to people. Many of the indicators developed for other themes are relevant to environmental health. Relevant indicators include:

- concentrations of carbon monoxide, sulfur dioxide, ozone (photochemical smog precursor), lead, nitrogen dioxide and particles (atmosphere)
- exposure to UVB radiation (atmosphere)
- compliance with water quality guidelines (inland waters)
- bio-accumulated pollutants (estuaries and the sea)
- drinking water quality (human settlements)
- food residues (land)

Further development of indicators for environmental health will be carried out in collaboration with the Australian Directors of Environmental Health.

ISSUE: Energy

(ANZECC: HS 1) ENERGY USE [PRESSURE]

Quantity of energy used in total, and in total as a percentage of GDP/GSP, for each of the following sectors: industry (manufacturing, mining, agriculture, and construction), services, transport, households and energy conversion.

Why is this indicator important?	Energy is fundamental to the operation of modern urban environments; it is central to the provision of goods and services, to production in industry, to mobility, to comfort, and to livability in the domestic context. It inevitably produces wastes which can be harmful to the environment, especially in the case of energy produced by burning fuels.
Why was this indicator selected?	This indicator shows changes in the patterns of energy use in Australia. Using less energy will generally be environmentally beneficial. This indicator satisfies all selection criteria, although there are some interpretational difficulties.
Current monitoring status	Data to support this indicator will be available through the ABS environmental accounting project. Raw data are collected by a number of agancies such as ABARE and ABS.
Development & interpretation issues	This indicator should be considered in tandem with the indicator “energy sources”. For interpretational purposes, it may be convenient to convert this indicator into a measure of energy intensity. This may be done for commercial sectors by considering the energy used per unit of GDP (or equivalent regional measure) and for domestic sectors by considering the energy used per capita. However, note that changes in energy use per unit GDP (or equivalent regional measure) do not necessarily indicate changes in efficiency. Structural changes in the relevant sector may also be implicated. Methodology is established.

[Newton et al: *HS 1.1-1.7]*

(ANZECC: HS 2) **ENERGY SOURCES** **[PRESSURE/RESPONSE]**

The sources of energy for sectors identified in the preceding indicator, and the amount of energy from each source. Sources to be classified as:

- **Renewable:**
  - **solar,**
  - **hydro,**
  - **wind,**
  - **wood,**
  - **other renewable.**
- **Non-renewable:**
  - **coal,**
  - **gas,**
  - **petroleum,**
  - **other non-renewable.**

Why is this indicator important?

Generating and consuming energy inevitably produces wastes, which can be harmful to the environment. Different sources of energy have different environmental consequences. For example, burning fossil fuels releases a range of gases and particles, but the mix of gases is different for natural gas, various grades of coal and petroleum. By contrast, using solar cells does not release gases or particles, but the manufacture of the cells may have environmental consequences.

Why was this indicator selected?

This indicator is a direct measure of the pressure.

Current monitoring status

Data to support this indicator will be available through the ABS environmental accounting project.

Development & interpretation issues

None.

Adopting established ABS methodology.

[Newton et al*: HS 1.1, 1.2, 1.4, 1.5 & 1.7]*

ISSUE: Water

(ANZECC: HS 3) **EXCEEDENCES OF DRINKING WATER QUALITY GUIDELINES** **[CONDITION]**

Drinking water quality for reticulated water supplies and proportion of the Australian population with access to drinking water systems, by settlement type (i.e. by major cities, other (coastal) cities, inland rural towns and remote settlements).

Why is this indicator important?	Access to quality drinking water is an important aspect of the environment as experienced by the inhabitants of human settlements.
Why was this indicator selected?	The Australian Drinking Water Guidelines (1996) are an accepted standard against which to evaluate the quality of drinking water.
Current monitoring status	Some data are available in all jurisdictions.
Development & interpretation issues	None. This indicator is restricted to human settlements with communal water supply systems and excludes individual households that are not connected to communal water supply systems. Methodology is established.

[Newton et al*: HS 2.1]*

ISSUE: Demographics

(ANZECC: HS 4) **URBAN GREEN SPACE** **[CONDITION]**

Area of urban land devoted to parks, gardens, recreation and other open spaces relative to total urban area. This indicator should be disaggregated into publicly accessible space and non-publicly accessible space (such as school grounds and some golf courses).

Why is this indicator important?	The amount, location and quality of green space in urban areas influences the quality of the urban environment for residents. Green space offers recreational opportunities and contributes to the aesthetics of the environment. Urban green space can also be important for biodiversity, for example by providing habitat for some species. This is not a measure of biodiversity.
Why was this indicator selected?	This indicator is a direct measure of the condition, and satisfies all selection criteria except ease of interpretation.
Current monitoring status	Some data are available, mainly from special purpose studies.
Development & interpretation issues	Interpretation of this indicator will be influenced by urban form (eg the type of green space, distance between green spaces, accessibility of green space). Normalising the indicator by comparing the area of green space to population or total urban area may also aid interpretation, since larger settlements may require more green space. Further clarification and development of this indicator would enhance its value. Methodology is established, although some definitional issues need better clarification.

[Newton et al: *HS 3. 3]*

(ANZECC: HS 5) **RESIDENTIAL DENSITY** **[CONDITION]**

Total resident population divided by the area of land within built residential zones.

Why is this indicator important?	Residential density strongly influences the environmental functioning of a human settlement. Low residential densities place pressure on local environments through encroachment on non-urban land and are associated with high energy and resource use. High residential densities can exacerbate pollution in large urban centres.
Why was this indicator selected?	This indicator is a direct measure of the condition, and satisfies all selection criteria except ease of interpretation.
Current monitoring status	Data to support this indicator are available from the ABS, and State and Territory planning agencies.
Development & interpretation issues	Environmental problems are associated with both high and low extremes of residential density (see above), and trends toward either extreme are likely to be unwelcome. It is less clear exactly which "mid point" is most desirable, and this may vary from settlement to settlement. Methodology is established however it needs to be consistently applied, and clarification of some definitional issues is required. *[Newton* et al: *HS 3. 4]*

(ANZECC: HS 6)	POPULATION DISTRIBUTION AND NUMBER OF PEOPLE PER DWELLING	[PRESSURE]

The absolute and percentage changes in population and number of households. Changes should be reported by location of the settlement (ie. whether coastal or inland) and by settlement size (ie. large, medium or small settlements).

Why is this indicator important?

Changing populations have major environmental effects. Settlements with growing populations are generally expanding, and therefore place additional pressure on the environment through development and increased human activity. Conversely, settlements with declining populations may lack the resources to address existing and emerging environmental concerns.

Why was this indicator selected?

The consequences of population growth or decline depend upon the location and size of the settlement. For example, coastal ecosystems are particularly fragile, and growth in coastal regions may require more careful management than elsewhere. Large cites may be better able than small settlements to sustain falls in population without endangering the capacity to respond effectively to local environmental concerns. Changes in number of household are as significant as shifts in population, because of the effect on demand for land and other resources.

Current monitoring status

This indicator is monitored across all jurisdictions by the ABS and State and Territory planning authorities.

Development & interpretation issues

None.

Methodology is standard.

[Newton et al: *HS 5.1]*

(ANZECC: HS 7) **VISITOR NUMBERS** **[PRESSURE]**

Annual numbers of visitors, by reason of visit and length of stay, relative to the resident population.

Why is this indicator important?	The effective size of the human population in each settlement depends upon the number of visitors as well as the resident population. Visitors make additional, and slightly different, demands on environmental and non-environmental resources to residents. It will only be necessary to report on this indicator for major tourist destinations.
Why was this indicator selected?	The extent to which visitors draw upon resources and affect the environment depends upon the length of the stay and the nature of the visit. For example, visitors staying with friends and relatives consume fewer resources than those staying in hotels and resorts.
Current monitoring status	Data relevant to this indicator are available in all jurisdictions.
Development & interpretation issues	The seasonal variation in visitor numbers is also important for many settlements. Peak visitor numbers may be a valuable adjunct to this indicator. Methodology is standard.

[Newton et al: *HS 5.4]*

ISSUE: Transport

(ANZECC: HS 8) **PUBLIC TRANSPORT USE** **[CONDITION]**

The number of trips made by public transport, by type.

Why is this indicator important?	The environmental effects of transport depend strongly upon the mode of transport used. Cars are generally the most, and walking and cycling the least, environmentally damaging modes of transport. Public transport is intermediate in its environmental effects. Increases in the number of trips made by public transport at the expense of travel by car would have environmental benefits.
Why was this indicator selected?	It is assumed that increased public transport use indicates reduced car use. Although this indicator is an imperfect measure of access to services, it is the best available measure.
Current monitoring status	Some relevant data are available from the Census. In some cities this is supplemented by additional surveys.
Development & interpretation issues	The link between mode of travel to work and overall choice of transport mode must be treated with caution. The mode of public transport used and the occupancy rates affect the environmental benefits of public transport. Methodology is established.

[Newton et al: *HS 4.1, 4.2, 4.5, 4.6 & 4.8]*

(ANZECC: HS 9) FUEL CONSUMPTION PER TRANSPORT OUTPUT [PRESSURE]

Megajoules of fuel consumed per passenger kilometre or tonne kilometre for each major transport mode, together with the total fuel consumption and passenger/freight kilometres travelled for each mode. This indicator should be reported by fuel type (petrol, unleaded petrol, diesel, LPG, natural gas, electric vehicles, and ethanol).

Why is this indicator important?	Transport is a major consumer of energy, and source of greenhouse gases and air pollutants.
Why was this indicator selected?	The energy consumed per unit of transport output is a measure of the efficiency of energy use by this sector. Lower energy consumption is likely to be environmentally beneficial.
Current monitoring status	Data necessary to calculate this indicator are available from the ABS, although it may be necessary to use vehicle kilometres travelled for private transport and passenger kilometres travelled for public transport.
Development & interpretation issues	None.
	Methodology is established.

[Newton et al: *HS 4.12]*

ISSUE: Waste

Note, the issue of contaminated sites is relevant to the human settlements theme. Hazardous wastes are reported by the National Pollutant Inventory (NPI).

(ANZECC: HS 10) SOLID WASTE GENERATION AND DISPOSAL [PRESSURE]

Solid waste generated per year split into:

- quantity and percentage disposed to landfill or incinerated, and
- quantity and percentage diverted from waste disposal facilities (reused, recycled or reprocessed) and reported for three waste streams recognised in the National Solid Waste Classification Scheme:
- municipal (domestic, other domestic, other council wastes),
- commercial and industrial, and
- building and demolition.

Why is this indicator important?	If managed improperly, waste can pollute the land, air or water. Minimising the amount of waste generated is an accepted strategy for dealing with this problem. Recycling is a key strategy for managing waste streams, with reduction of waste to landfill a major aim.
Why was this indicator selected?	This indicator is a direct measure of the pressure.
Current monitoring status	Monitoring is currently patchy, but this is improving as the Australian Waste Database (AWD) is implemented.
Development & interpretation issues	The Australian Waste Database will allow waste streams to be analysed at a finer level of detail than required by this indicator. These details will help analyse and interpret trends. While hazardous waste should also be reported, there are differences in definition, and it is not covered by the Australian Waste Database. Adopted established AWD and NPI methodologies.

[Newton et al: *HS 10.1-10.4]*

ISSUE: Community attitudes and actions

(ANZECC: HS 11) COMMUNITY ATTITUDES AND ACTIONS [RESPONSE]

Trends in people's attitudes and actions, derived from ABS surveys.

Why is this indicator important?	The attitudes and actions of individual Australians are an important factor in their impact on the environment (as individuals or as members of households). Surveying community attitudes is an important feedback mechanism for analysing the effectiveness of environmental policies, programs and education, as well as for judging support for initiatives.
Why was this indicator selected?	This indicator is a measure of individual people's attitudes and some of their individual actions in response to their perception of the condition of the Australian environment and the pressures upon it.
Current monitoring status	Longitudinal surveys are essential for data on trends. The Australian Bureau of Statistics has undertaken regular surveys of people's views and practices since 1992. This work can be supplemented by other ABS surveys and by ad hoc surveys by other organisations.
Development & interpretation issues	None. Note, only civilians over 18 years of age are surveyed. The indicator covers: Appendix 4 environmental concerns, Appendix 4 priority of environmental objectives (less, equal or greater than economic objectives) Appendix 4 individual and household actions in response to peoples' perceptions of the condition of the Australian environment and the pressures upon it. Methodology is established. *[Developed by ANZECC SoER Task Force]*

Recent Australasian Reports on the State of the Environment (since 1988)

Jurisdiction	Examples of recent reports	Scope *	Prepared by	Frequency	Legislative requirement?	Further information
Commonwealth of Australia	*Australia: State of the Environment 1996* Next report due in 2001	Comprehensive by broad environmental themes	Environment Australia, overseen by the independent Australian State of the Environment Committee	5 years	Yes	Environment Australia GPO Box 787 Canberra ACT 2601 Website: http: / / www.erin. gov.au / portfolio / dest / soe / soe96 / soe 96.html
New Zealand	*The State of New Zealand's Environment 1997*	Comprehensive by broad environmental themes	Ministry for the Environment		No	Ministry for the Environment PO Box 10362 Wellington, New Zealand
New South Wales	*New South Wales: State of the Environment 1993* *New South Wales: State of the Environment 1995* *New South Wales: State of the Environment 1997*	Comprehensive by broad environmental themes	Environment Protection Authority	3 years	Yes	Information Centre – NSW EPA 59 Goulburn Street SydneyNSW 2000 (PO Box 1135 Chatswood NSW 2057) Website: http: / / www.epa. nsw.gov.au / soe / 97
Queensland	*State of the Environment Queensland 1999*	Comprehensive by broad environmental themes	Environment Protection Authority, through sectoral working groups	4 years	Yes	PO Box 155 Brisbane Albert Street QLD 4002
South Australia	*The State of the Environment Report for South Australia (1988)* *The State of the Environment Report forSouth Australia 1993* *State of the Environment Report for South Australia 1998*	Comprehensive by environment-al issues. Priority issues are identified.	Environment Protection Authority, Natural Resources Council, and Department of Environment, Heritage and Aboriginal Affairs	5 years	Yes	Natural Resources Information Centre DEHAA 77 Grenville Street SA 5001
Tasmania	*State of the Environment Tasmania Volume 1 – Conditions and Trends (1996)* *State of the Environment Tasmania Volume 2 – Recommendations (1997)*	Comprehensive by broad environmental themes, with recommendations	Resource Planning and Development Commission	5 years	Yes	Land Information Services Sales Ground Floor 134 Macquarie Street HobartTasmania7000 Website: http: / / www.rpdc. tas. gov.au / soe_reporting / soe_docs / soe_reporting.htm
Victoria	*Know Your Catchments, Victoria 1997: an assessment of catchment condition using interim indicators*	Broad environmental themes within Catchments.	Department of Natural Resources and Environment, Victorian Catchment and Land Protection Council, and Victorian Environment Protection Authority		Not for the actual document, although fulfilled part of legislative requirements.	

* Current scope: The scope of earlier reports may have been different.

Recent Australasian Reports on the State of the Environment (since 1988)

Examples of Jurisdiction	recent reports	Scope *	Prepared by	Frequency	Legislative requirement?	Further information
	Victoria's Biodiversity: Directions in Management 1997	Biodiversity	Department of Natural Resources and Environment	Once off	Produced as part of strategy required due to legislation.	NRE Information Centre 8 Nicholson Street PO Box 500 East Melbourne, Victoria 3002
	Environmental Health of Streams in the Western Port Catchment, April 1998.	Health of rivers and streams	Victorian Environment Protection Authority	Ongoing for each catchment	No	NRE Information Centre 8 Nicholson Street PO Box 500 East Melbourne, Victoria 3002 Website: http: / / www.nre. vic.gov.au / catchmnt / conditn /
	Air Monitoring Data 1992-1995, Publication 584 (October 1977)	Air quality	Victorian Environment Protection Authority	Annual	Yes	Customer Service & Information Centre VIC EPA 3rd Floor, HWT Tower 40 City Road Southbank, Melbourne Victoria 3006
Western Australia	*Draft State of the Environment Report for Western Australia (1997)* *Draft Working Papers (8 volumes) (1997)* *Environment Western Australia 1998–State of the Environment Report*	Priority issues Priority issues by regions Priority issues	Reference group comprising representatives of relevant Government and Statutory bodies (Department of Environment Protection)	3-4 years	No	Department of Environmental Protection Westralia Square 141 St Georges Terrace PerthWA6000 Website: http: / / www. Environ.wa.gov.au
Australian Capital Territory	*Australian Capital Territory State of the Environment Report 1994* *Australian Capital Territory State of the Environment Report 1995* *Australian Capital Region State of the Environment Report 1997 (CD-ROM only)* – for the ACT and surrounding local governments, and *"ACT State of the Environment Report 1997 Executive* Summary and Recommendations" (mimeo) Commissioner for the Environment's *Annual Report* (1997–98 and 1998–99) for responses and government actions respectively to ACT 1977 SoE report recommendations.	Comprehensive by broad environmental themes, with recommendations	ACT Office of the Commissioner for the Environment Commissioner for the Environment	Annual Annual 3 years	Yes	Office of the Commissioner for the Environment PO Box 3196 Canberra ACT 2601 Website: http: / / www.EnvComm.act.gov.au

* Current scope: The scope of earlier reports may have been different.

APPENDIX 2

ENVIRONMENTAL INDICATORS REPORTS

The scientific and technical basis for the indicators in this report is found largely in work commissioned by Environment Australia.This work is publicly available in the form of the following reports:

Alexandra J., J. Higgins and T. White (1998) *Environmental indicators for national state of the environment reporting - Local and Community Uses*, Australia: State of the Environment (Environmental Indicator Reports), Department of the Environment, Canberra.

Fairweather P. and G. Napier (1998) *Environmental indicators for national state of the environment reporting - Inland waters*, Australia: State of the Environment (Environmental Indicator Reports), Department of the Environment, Canberra.

Hamblin A. (1998) *Environmental indicators for national state of the environment reporting - The Land*, Australia: State of the Environment (Environmental Indicator Reports), Department of the Environment, Canberra.

Manton M. and D. Jasper (1998) *Environmental indicators for national state of the environment reporting -Atmosphere*, Australia: State of the Environment (Environmental Indicator Reports), Department of the Environment, Canberra.

Newton P., J. Flood, M. Berry, K. Bhatia, S. Brown, A. Cabelli, J. Gomboso, J. Higgins, A. Richardson and V. Richie (1998) *Environmental indicators for national state of the environment reporting - Human settlements*, Australia: State of the Environment (Environmental Indicator Reports), Department of the Environment, Canberra.

Pearson M., D. Johnston, J. Lennon, I. McBryde, D. Marshall, D. Nash and B. Wellington (1998) *Environmental indicators for national state of the environment reporting – Natural and Cultural Heritage*, Australia: State of the Environment (Environmental Indicator Reports), Department of the Environment, Canberra.

Saunders D., C. Margules and B. Hill (1998) *Environmental indicators for national state of the environment reporting - Biodiversity*, Australia: State of the Environment (Environmental Indicator Reports), Department of the Environment, Canberra.

Ward T., E. Butler and B. Hill (1998) *Environmental indicators for national state of the environment reporting - Estuaries and the Sea*, Australia: State of the Environment (Environmental Indicator Reports), Department of the Environment, Canberra.

The above reports can be found on the Internet at: **http://www.erin.gov.au/environment/epcg/soe.html**

Two state governments have also produced discussion papers on state of the environment reporting and indicators:

(a) New South Wales:

Environment Protection Agency (1996) *The Future of NSW - State of the Environment Reporting* Discussion Paper, NSW EPA, Sydney.

(b) South Australia:

Department of Environment, Heritage and Aboriginal Affairs (1999) *Environmental Performance Measures: Signposts to the Future*, DEHAA, Adelaide.
and
Environment Protection Authority, Natural Resources Council and Department of Environment and Natural Resources (1997) *Environment Reporting in South Australia*, EPA/NRC/DENR, Adelaide.

A useful introduction was jointly developed by CSIRO and Environment Australia:

Heinemann D., J. Higgins, G. McAlpine, J. Raison, S. Ryan and D. Saunders (1988) *A guidebook to environmental indicators*, CSIRO, Canberra.

In addition, the Australian Local Government Association and Environment Australia have produced an introduction to indicator selection: Australian Local Government Association (1999) *Choosing and using environmental indicators*, ALGA, Canberra.

APPENDIX 3

NEW ZEALAND WORK ON INDICATORS

The New Zealand Ministry for the Environment is co-ordinating the development of a core set of national environmental performance indicators under the Environmental Performance Indicators (EPI) Program.The purpose of the EPI Program is to develop and use indicators to measure and report on how well New Zealand is looking after its environment.The Ministry has worked with a wide range of different people and organisations to develop and confirm indicators during 1997-1999.The Ministry has:

- implemented indicators for air, ozone and climate change;
- initiated implementation of indicators for land and freshwater
- developed proposed indicators for the marine environment, biodiversity and waste;
- developed proposed indicators for waste, hazardous substances and toxics, the marine environment, and terrestrial and freshwater biodiversity;
- started work on transport indicators;
- commissioned work on indicators of urban amenity;
- completed an analysis of all district and city council state of the environment monitoring;
- progressed work on the information management system for the storage and organisation of environmental information;
- progressed Maori relevant indicators work by:
  - setting up a Maori Environmental Monitoring Group to provide strategic input into the EPI Program
  - contracting work on Maori indicators on all active components of the EPI Program
  - developing three case studies with Iwi on indicators.

Later priorities for the EPI will be to develop indicators for energy, pests, weeds and diseases.

The Ministry has produced the following publications:

Ministry for the Environment (1997) *Environmental Performance Indicators: Proposals for air, fresh water and land*. MfE, Wellington NZ.

Ministry for the Environment (1998) *Environmental Performance Indicators: Proposals for stratospheric ozone and climate change*. MfE, Wellington NZ.

Ministry for the Environment (1998) *Environmental Performance Indicators: Confirmed indicators for air, fresh water and land*. MfE, Wellington NZ.

Ministry for the Environment (1998) *Environmental Performance Indicators: Proposals for waste and hazardous substances.* MfE, Wellington NZ.

Ministry for the Environment (1998) *Environmental Performance Indicators: Proposals for the marine environment.* MfE, Wellington NZ.

Ministry for the Environment (1998) *Environmental Performance Indicators: Proposals for terrestrial and freshwater biodiversity*. MfE, Wellington NZ.

Ministry for the Environment (1998) *Environmental Performance Indicators: Summary of proposals for waste, hazardous substances and toxic contaminants.* MfE, Wellington NZ.

Ministry for the Environment (1998) *Environmental Performance Indicators: Summary of proposed indicators for the marine environment*. MfE, Wellington NZ.

Ministry for the Environment (1998) *Environmental Performance Indicators: Summary of proposed indicators for terrestrial and freshwater biodiversity*. MfE, Wellington NZ.

Ministry for the Environment indicators home page: **http://www.mfe.govt.nz/monitoring/indicators.htm**

APPENDIX 4

LIST OF ABBREVIATIONS

A	Atmosphere theme
ABS	Australian Bureau of Statistics
ABARE	Australian Bureau of Agricultural and Resource Economics
ACLEP	Australian Collaborative Land Evaluation Program
AFFA	Department of Agriculture, Forestry and Fisheries
ANZECC	Australian and New Zealand Environment and Conservation Council, a body comprising of all Commonwealth, State and Territory environment and conservation Ministers
ARMCANZ	Agriculture and Resource Management Council of Australia and New Zealand,
AUSLIG	Australian Land Information Group
AUSRIVAS	Australian River Assessment Scheme
BD	Biodiversity theme
BRS	Bureau of Rural Sciences (neé Bureau of Resource Sciences)
CFCs	chlorofluorocarbons
COAG	Council of Australian Governments
DEHAA	Department of Environment, Heritage and Aboriginal Affairs
DPIE	Department of Primary Industries and Energy (NOTE: in 1998 the minerals and energy part of DPIE was transferred to the Department of Industry, Science and Resources and the remainder of the department was re-named Department of Agriculture, Forestry and Fisheries Australia)
E+S	Estuaries and the Sea theme
EFO's	Environmental Flow Objectives
EPA	Environment Protection Agency
ESD	Ecologically Sustainable Development
GDP	Gross Domestic Product
GSP	Gross State Product (i.e. for a state or territory)
HS	Human Settlements theme
IBRA	Interim Biogeographic Regionalisation for Australia
IMCRA	Interim Marine and Coastal Regionalisation for Australia
IUCN	World Conservation Union (neé International Union for Conservation of Nature)
IW	Inland Waters theme

L	Land theme
MRL	Maximum residue levels
NCPISA	National Collaborative Project on Indicators of Sustainable Agriculture
NEPMs	National Environment Protection Measures
NGGI	National Greenhouse Gas Inventory
NHMRC	National Health and Medical Research Council
NLWRA	National Land and Water Resources Audit
NPI	National Pollutant Inventory
NRE	Natural Resources and Environment
NVIS	National Vegetation Information System
ODS	Ozone Depleting Substance
OECD	Organisation for Economic Co-operation and Development
SCARM	Standing Committee on Agriculture and Resource Management
UV	Ultra-violet radiation from the sun
UVB	Ultra-violet radiation in the wavelength range 280-320 nanometres

APPENDIX 5

GLOSSARY

Acidification	A gradual increase in the acidity of a soil as a consequence of a variety of natural processes and management actions.
Airshed	A body of air bounded by topographical and/or meteorological features in which a contaminant, once emitted, is contained.
Algal blooms	A sudden proliferation of microscopic algae in water bodies, stimulated by the input of nutrients such as Phosphorus.
Alien species	See introduced species.
Aquaculture	The commercial growing of marine (mariculture) or freshwater animals and plants in water.
Artesian bore	A bore sunk through impermeable strata into strata receiving water from an area at a higher altitude than that of the bore, so the water is forced to flow upwards.
Bare soil	Soil without a cover of live or dead vegetation to protect it from erosion.
Benthic	Referring to organisms living in, or on, the sediments of aquatic habitats (lakes, rivers, ponds, etc.).
Best practice	The practice of seeking out, emulating and measuring performance against the best standard available.
Bio-accumulation	General term describing a process by which chemical substances are accumulated by organisms from contact and/or ingestion of water, food and/or air containing the chemicals.
Biodiversity	The variety of all life forms: the different plants, animals and micro-organisms, the genes they contain and the ecosystems they form; often considered at three levels: *genetic diversity*, *species diversity* and *ecosystem diversity*.
Biogeographic range	The geographical distribution of plants and animals at different taxonomic levels, past and present.
Carbon dioxide (CO_2)	A normal constituent of the atmosphere, relatively innocuous in itself but playing a highly significant role in the *enhanced* greenhouse effect. A product of fossil fuel combustion and biological respiration. An essential input in photosynthesis, to produce sugars and all carbohydrates.
Carbon monoxide (CO)	A colourless odourless gas that is readily combined with the haemoglobin of the blood to produce carboxy-haemoglobin, thus inhibiting the absorption of oxygen. The principle source of CO in the general atmosphere is from motor vehicle exhaust gases.
Clearing	Removing vegetation, particularly trees and shrubs, from a landscape, often with the intention of replacing it with plants regarded to be more directly useful to humans.
Condition indicators	Something that describes the quality of the environment and the quality and quantity of natural resources; highlights changes in environmental conditions over time.

Core Indicators	A subset of environmental indicators that are applicable to both national and State/Territory state of the environment reporting.
Discarded catch	The portion of unsaleable catch that is dumped, dead or alive, during or after fishing operations.
Dobson spectrophotometer	The Dobson spectrophotometer plays a key role in ground-based ozone monitoring efforts. Invented in the late 1920's by G.M.B. Dobson, this instrument divides sunlight into a spectrum with a prism and measures the ratio of two UV wavelengths about 20 nanometers (nm) apart. Dust and aerosols can cause errors in ozone observations by scattering one wavelength more than another. Dobson observations are usually made at two pairs of wavelengths to cancel out this error.
Ecological Community	An assemblage of native species that inhabits a particular area.
Ecosystem	A dynamic complex of plant, animal and micro-organism communities and their non-living environment interacting as a functional unit.
El Niño	A warm water current which periodically flows southwards along the coast of Ecuador and Peru in South America, replacing the usually cold northwards flowing current; occurs once every five to seven years usually during the Christmas season (the name refers to the Christ child). Occasionally (eg 1925, 1972–73, 1982–83 and 1990–94) the occurrence is major and prolonged; the opposite phase of an El Niño event is called a La Niña see *ENSO*.
Endangered	Under the *Commonwealth Endangered Species Protection Act 1992* and *Environment Protection and Biodiversity Conservation Act 1999*, a species is endangered if: it is likely to become extinct unless the circumstances and factors threatening its abundance, survival or evolutionary development cease to operate; or its numbers have been reduced to such a critical level, or its habitats have been so drastically reduced, that it is in immediate danger of extinction; or it might already be extinct, but is not presumed extinct.
Enhanced greenhouse effect	Changes in the earth's climate as a result of increasing levels of greenhouse gases in the atmosphere due to human activity.
ENSO (El Niño –Southern Oscillation)	A suite of events that occur at the time of an El Niño; at one extreme of the cycle, when the central Pacific Ocean is warm and the atmospheric pressure over Australia is relatively high, the ENSO causes drought conditions over eastern Australia see El Niño, Southern Oscillation.
Environmental flows	The components of river flows that are considered essential for the maintenance of a river ecosystem, including floodplains and associated wetlands.
Environmental health	The professional practice of improving and preserving residential and industrial hygienic, environmental and housing for individuals and communities, and improving and preserving public health and allied matters, including the control and management of the total environmental and ecological balance by educational processes and enforcement of statutory provisions and by the application of preventative science and practice.
Environmental Indicators	Physical, chemical, biological or socio-economic measures that can be used to assess natural resources and environmental quality.
(presumed) Extinct	Under the *Commonwealth Endangered Species Protection Act 1992* and *Environment Protection and Biodiversity Conservation Act 1999*, a species is presumed extinct at a particular time if:it has not been definitely located in nature during the preceding 50 years; or it has not been definitely located in nature during the preceding 10 years despite thorough searching during the period.

Feral animals	Animals that have reverted to a wild state from domestication (for example, feral cats, pigs, donkeys etc).
Fire regime	the pattern of fires at a location; includes the type (e.g. peat, crown etc) frequency, intensity and seasonality of the fires.
Genetic diversity	The diversity of individual genomes within a population of a specific species. A certain level of diversity is required for the long-term viability of that population. More broadly a variation in the genetic composition between individuals, populations and species.
Genetically modified organisms	Organisms whose genetic make up has been altered by the insertion or deletion of small fragments of DNA in order to create or enhance desirable characteristics from the same or another species.
Greenhouse gas	Gas which affect the temperature of the earth's surface. The main ones include; water vapour(H_2O), Tropospheric ozone (O_3), chlorofluorocarbons (CFCs), carbon dioxide (CO_2), methane(CH_4), and nitrous oxide (N_2O). The last three gases are of particular concern because they take a long time to be removed from the atmosphere. CFCs are controlled separately by the Montreal Protocol due to their ability to damage the ozone layer in the stratosphere.
Habitat	The place where an animal or a plant normally lives and reproduces.
Halocarbons	A chemical group of carbon-based compounds combined with halogens (Chlorine, Fluorine etc.).
Heavy metal	Metallic element with relatively high atomic mass (over 5.0 specific gravity), such as lead, cadmium, arsenic and mercury; generally toxic in relatively low concentrations to plant and animal life.
Hierarchical vegetation classification	The grouping of plant species by a series of subdivisions or agglomerations to form a characteristic "family tree" (dendrogram) of groups.
Intensive land use zone	Cropping and grazing areas excluding the extensive pastoral zones of SA, NT, Queensland and WA.
Intertidal	Between the levels of low and high tide; (the intertidal zone is often called the *littoral* zone in Australia).
Introduced species	A species occurring in an area outside its historically known natural range as a result of intentional or accidental dispersal by human activities (including exotic organisms, genetically modified organisms and translocated species).
Kyoto Protocol	An international agreement, reached in 1997 in Kyoto, Japan, which extends the commitments of the United Nations Framework Convention on Climate Change. In particular, it sets targets for future emissions by each developed country.
Landed by-catch	Species taken incidentally in a fishery where other species are the target; usually of lesser value than the target species but can be commercially important and also may consist of ecologically sensitive species.
Limiting factor	A factor which limits the population size or growth potential such as water or Phosphorus availability.
Littoral	Of or pertaining to a shore, especially a seashore; littoral zone – the specific zone of the sea floor lying between high and low tide levels (*intertidal*).
Macro-invertebrates	Invertebrate water dwelling animals (such as; snails, crustacea, insect larva and worms) visible to the naked eye.

Marine habitat	Saltwater environment associated with estuaries and/or the sea (see habitat).
Maximum residue levels (MRL)	Maximum concentration of contaminants (pesticides, heavy metals etc.) allowable in food and produce as defined by the Australian and New Zealand Food Authority.
Median particles (PM_{10})	Particulate matter smaller than 10 microns in diameter.
Methane (CH_4)	Simple hydrocarbon produced by the anaerobic decomposition of organic matter.
National Vegetation Information System (NVIS)	A system currently being developed by the Commonwealth Departments of the Environment and Heritage, and Agriculture, Forestry and Fisheries, in colloboration with State and Territory environmental and natural resource agencies, to collate and present Australia-wide vegetation data.
Non-indigenous species	See introduced species.
Ozone	A gas with molecules comprising three atoms of oxygen; in the stratosphere it occurs naturally and provides a protective layer shielding the Earth from ultraviolet radiation; in the troposphere, it is usually formed from anthropogenic emissions and is a major component of photochemical smog; ozone is also a greenhouse gas.
Pest	A general term describing an animal or plant that is directly harmful to the health of people, or that has a negative impact on a valuable resource and requires some form of action to reduce that impact.
Photochemical smog	Air pollution caused by chemical reactions among various substances and pollutants in the atmosphere in the presence of sunlight; ozone is a major constituent.
PM_{10}	Particulate Matter less than 10 µm in diameter Known as PM_{10}.
Population dynamics	Population Dynamics refers to the density of organisms inhabiting a specific area or habitat, and the change in this density over time and space.
Pressure indicator	Measure that can be used to describe both positive and negative pressures on the environment, including the quality and quantity of natural resources; such pressure can be caused by human inaction as well as action.
Recharge	The volume of water that is added to the total amount of groundwater in storage in a given period of time.
Recovery plans	A recovery plan provides for the research and management actions necessary to stop the decline of a threatened species so that its chances of long term survival in nature are maximised.
Response indicator	Indicator that shows the extent to which society is responding to environmental changes and concerns; includes changes in attitude and individual and collective actions aimed at mitigating, adapting to or reversing negative impacts on the environment and reversing environmental damage already caused; also includes actions to improve the preservation and conservation of the environment.
Revegetation	The process by which the density of vegetation (trees, shrubs, grasses) within a particular area increases either through natural processes (e.g. from existing seedbanks) or human activities (e.g. planting of seedlings).
Riparian	Pertaining to river-banks.
Salinisation	The process by which soluble salt levels in the soil increase to the point where plant growth is affected.

Southern Oscillation Index	An indicator based on the pressure gradient between the quasi-stationary low pressure region over Indonesia and the centre of the subtropical high pressure cell over the eastern Pacific Ocean; traditionally, Darwin and Tahiti are used as the sites for determining the magnitude of the Southern Oscillation; a negative SOI is associated with higher than normal pressures over Darwin and drought conditions over much of eastern Australia.
Species	A group of plants, animals or micro-organisms that have a high degree of similarity and generally can interbreed only amongst themselves to produce fertile offspring, so that they maintain their 'separateness' from other such groups.
State of the environment reporting	A process that provides a scientific assessment of environmental conditions, focusing on the impacts of human activities, their significance for the environment and societal responses to the identified trends.
Subsistence catch	Catch of marine wildlife taken by traditional fishing peoples and practices for the purpose of food or ceremony.
Sulfur dioxide (SO_2)	The gaseous product of the oxidation of Sulfur, which is released into the atmosphere, when fuels containing sulfur are burned. SO_2 is the main cause of acid precipitation.
Sustainable resource use	A management goal in which the rate of harvesting or use does not exceed the rate of renewal of the resource over a prescribed time.
Threatening processes	A threatening process is a process that threatens, or may threaten, the survival, abundance or evolutionary development of a native species or ecological community.
Ultra-violet radiation	Electromagnetic radiation of higher frequencies and shorter wavelengths than visible light; ultraviolet radiation is divided into three ranges: UV-A (320–400 nm), UV-B (280–320 nm) and UV-C (40–290 nm).
Vulnerable species	Under the *Commonwealth Endangered Species Protection Act 1992* and *Environment Protection and Biodiversity Conservation Act 1999*, a species is vulnerable at a particular time if:within the next 25 years, the species is likely to become endangered unless the circumstances and factors threatening its abundance, survival or evolutionary development cease to operate.
Waste water	Water discharges from domestic effluent, industrial (trade waste, industrial waste) and other sectors.
Watertables	A surface defined by the level to which water rises in an open well or piezometer.
Weed	A weed can be considered as any plant that is having a negative impact on a valuable resource and requires some form of action to reduce that impact.
Wetlands	Any land thought to be naturally wet, either permanently or intermittently.

CORE ENVIRONMENTAL INDICATORS FOR REPORTING ON THE STATE OF THE ENVIRONMENT

This report presents a set of core environmental indicators for reporting on the state of the environment. These were identified and developed by the State of the Environment Reporting Task Force of the Australian and New Zealand Environment and Conservation Council (ANZECC). The indicators cover six of the state of the environment reporting themes: the atmosphere, biodiversity, the land, inland waters, estuaries and the sea, and human settlements. Indicators for the seventh theme, natural and cultural heritage, are being developed through a separate process.

This core set of environmental indicators was endorsed in December 1999 by ANZECC Ministers. ANZECC recognises that the core set will continue to evolve as the suitability and applicability of the indicators are demonstrated through use by the Australian community. Further indicators may be added as understanding of the environment and methodologies for data collection and analysis continue to improve. Together with the more specific indicators currently in use by the Commonwealth, various States, Territories and Local Government, core indicators will help to build a consistent picture of trends in the Australian environment.