

**Environmental indicators for State of
the Environment reporting**

Jonet C. Ward

August 1990

INFORMATION PAPER NO. 21



**CENTRE FOR
RESOURCE MANAGEMENT**

ENVIRONMENTAL INDICATORS
FOR STATE OF THE ENVIRONMENT REPORTING

Jonet C. Ward

August 1990

Information Paper No. 21
Centre for Resource Management
Lincoln University and University of Canterbury



1990

Centre for Resource Management
P.O. Box 56,
Lincoln University,
Canterbury, New Zealand.

ISSN 0112-0875
ISBN 1-86931-046-2

The Centre for Resource Management is a research and teaching organisation spanning the campuses of the University of Canterbury and Lincoln University in Canterbury. Research at the Centre is focused on the development of conceptually sound methods for resource use that may lead to a sustainable future. The Centre for Resource Management acknowledges the financial support received from the Ministry for the Environment in the production of this unpublished report.

The Centre for Resource Management offers research staff the freedom of inquiry. Therefore, the views expressed in this unpublished report are those of the author and do not necessarily reflect those of the Centre for Resource Management.

Contents

Acknowledgements

Executive summary	i
1. Introduction	1
2. Definitions	2
3. Environmental monitoring research in New Zealand	3
4. Environmental indicators	4
4.1 Criteria for choosing appropriate environmental indicators	5
4.2 Indicators in State of the Environment reporting	6
5. Frameworks for State of the Environment reporting	8
6. Questionnaire on management objectives and indicators	15
7. Management objectives and indicators of environmental response to stress	16
8. Indicators related to agency outcomes	26
9. Extending the State of the Environment reporting process	28
9.1 Environmental trend indications	29
9.2 Performance indicators	34
10. Valued environmental components (vecs)	37
10.1 Management implications of valued environmental components	41
11. Conclusions	43
12. Recommendations	45
13. References	46
Appendix 1	49
Appendix 2	52

Acknowledgements

This work was undertaken for the Ministry for the Environment and benefited from the guidance of E. Goldberg.

The author would like to thank Drs D.G. Smith and R.J. Davies-Colley (Water Quality Centre, DSIR, Hamilton) for reviewing the report and providing many useful suggestions. Thanks also go to Dr. W.M. McEwen (formally Department of Conservation, now Office of Parliamentary Commissioner for the Environment) for helpful comments, to Tracy Williams (Centre for Resource Management) for editorial assistance and to Carmel Edlin (Centre for Resource Management) for help with the tables.

Executive summary

The Ministry for the Environment is proposing that a State of the Environment reporting system should be prepared for New Zealand. This would require participation by agencies concerned with environmental management along with certain information requirements. This publication aims to provide the Ministry with examples of indicators that could be used in a State of the Environment Report (SER) and are relevant to the objectives of management agencies.

A questionnaire was sent to central government agencies and catchment authorities in July 1989 to obtain an overview of current environmental monitoring in this country. The responses showed that because of reorganisation of central government agencies there has been a marked shift towards short-term client-oriented work at the expense of long-term monitoring programmes. An SER requires a commitment to long-term monitoring.

Monitoring involves the repeated measurement of particular environmental attributes such as temperature, pH, rainfall, plant density, animal numbers etc. From these environmental variables, indicators may be selected that inform us about the state of the environment omitting the need to peruse all the environmental variables that have been measured.

Since the environment is a complex mosaic of interrelated components, no single indicator can fully describe the state of the environment and how it is changing. The choice of appropriate environmental indicators must be related to the problem or objectives of the study.

Environmental indicators should be capable of identifying changes in environmental conditions (quantity and quality) and the agents of these changes, be understandable to the general public, be limited in number, be scientifically based and valid, be sensitive to time and space, be based on relative ease of data collection, and provide early warning of environmental damage.

Indicators used in SERs include environmental indicators and may also include social indicators, indicators of sustainability, policy indicators etc. A truly comprehensive set of indicators for an SER would not only describe environmental conditions (quantitative and qualitative) but also the causes of environmental change (human and natural processes). The development of meaningful indicators for an SER requires the identification of clear, precise objectives by the agency responsible for the management of the resource.

In order to develop useful indicators for an SER, some type of framework is needed to organise the information that is collected according to the required objectives. Various organisational and spatial frameworks are used in SERs. Examples are given of organisational frameworks that are based on the Canadian stress-response approach and this framework was considered a suitable starting point for New Zealand. An appropriate spatial framework would be the New Zealand ecological districts.

After modification for New Zealand conditions and comments from respondents to the July 1989 questionnaire, the stress-response framework was used to guide a list of suggested environmental indicators based on management objectives. The framework divides the objectives and indicators into the following forms of stress: natural, population, harvesting, use of renewable energy resources, extraction and depletion of non-renewable resources, environmental modification, waste generation. The agency responsible for management is suggested at the end of each section.

The management objectives listed within the framework were found to be very similar to the environmental “outcomes” of some central government agencies. In order to focus on specific agencies, an attempt was made to relate their outcome statements, as listed in the corporate plans, to the environmental indicators that had been suggested. For example, one outcome in the Ministry of Agriculture and Fisheries corporate plan is the preservation of New Zealand’s environment and its international standing as free from disease, pests and residues in animals, plants, fish and foods. Indicators of this outcome could be: incidence of disease and pollution, area occupied by nuisance species, and indicators of soil, air and water quality to meet set standards.

Difficulty in this exercise arose because the outcomes stated in some corporate plans are not clear management objectives. If clear management objectives are stated, indicators can be selected to tell us whether the agency is achieving its objectives. For State of the Environment reporting, it would be useful for those agencies with environmental management responsibilities to have the agency’s management objectives along with carefully selected environmental indicators stated in the corporate plan.

State of the Environment reporting goes beyond identifying indicators of the state of the environment. An understanding of environmental processes is necessary to evaluate the appropriateness of existing policies, programmes and management practices and to implement remedial action to manage environmental resources effectively.

Assessment of policy in an SER can take place in a number of ways. Environmental trend indications graphically combine trends in environmental quality and environmental policy. Examples are given from the Netherlands and New Zealand. In Norway, environmental accountability has been introduced and must be discussed in the annual report of every central government agency. In New Zealand, some government agencies list performance measures in their corporate plans to indicate the extent to which their policy outcomes have been fulfilled. If performance measures were applied to environmental management objectives and listed in corporate plans, the SER process could serve to check environmental accountability.

Management agencies and regional and local authorities need some indicators of public awareness and support for environmental matters so that they are in a better position to manage the environment on behalf of the people of New Zealand. Valued environmental components (vecs) provide a link between science and the lay perceptions of the environment. The value that people place on aspects of the environment depends upon their cultural, social and educational background and on whether, or how, they intend to use the particular environment component.

For management, vecs must first be identified by observation of people's behaviour and attitudes or by questionnaires and interviews, then periodic feedback through public participation should allow the resource to be managed for its values to people. Appropriate indicators of the condition of the vecs can be used to assess any change. On-going communication between management agencies and the tangata whenua, interest groups and individuals must take place so that their perceptions and values can be incorporated into management.

Recommendations for a State of the Environment reporting system include the necessity for a commitment by government to provide funding for long-term environmental monitoring. The environmental indicators suggested in this publication need to be circulated to management and monitoring agencies for discussion, modification and augmentation followed by communication with the Ministry for the Environment to ensure that there are no gaps or unnecessary overlaps. On-going communication between management agencies and the public must be facilitated so that perceptions and values with respect to the environment can be incorporated into management. Corporate plans or statements of intent should be used to set out clear management objectives and environmental indicators along with an assessment of the effectiveness of policy so that the SER process can be used to check environmental accountability.

1. Introduction

The Ministry for the Environment is proposing that a State of the Environment reporting system should be prepared for New Zealand (Goldberg 1990). This would require participation by agencies concerned with environmental management along with certain information requirements. Goldberg (1990) suggests that a State of the Environment Report (SER) involves three elements:

- * indicators physical, chemical, biological, social or economic attributes, or combined as valued environmental components (vecs),
- * rules objectives, standards, policies, regulations, legislation,
- * efficiency value for money, performance, accountability, surveillance.

This publication is concerned mainly with indicators. It aims to provide the Ministry with examples of indicators that could be used in an SER and are relevant to the objectives of management agencies. The choice of appropriate indicators needs care and is related to the information that is required from data collected by environmental monitoring.

The study follows on from a review of State of the Environment reporting in other countries and environmental monitoring in New Zealand (McRae *et al.* 1989).

2. Definitions

Some terms are used differently in the literature resulting in confusion. The following definitions apply to this publication.

Environmental indicators reflect changes in the state of the environment.

Environmental monitoring is the resurveying and assessment of environmental change.

Indices are computed functions of variables that integrate the data pool in some way.

Outcomes are government objectives.

Outputs are goods and services produced by government departments.

Performance indicators reflect the extent to which objectives and/or policies have been fulfilled.

Quality means character

State of the Environment Report (SER) is a systematic analysis of environmental conditions and trends.

Valued environmental components (vecs) are environmental components that are perceived as having value.

3. Environmental monitoring research in New Zealand

Monitoring can take place at two levels:

- * monitoring decision-making processes i.e. monitoring the effectiveness of policies and the achievement of objectives,
- * monitoring the condition or state of the environment.

Links can be made between the two levels (McRae *et al.* 1989). An SER is one product of monitoring the condition of the environment.

An informal survey of central and local government agencies in early 1989 indicated that although considerable environmental monitoring was being carried out in New Zealand, it was constrained by a lack of funding and expertise (McRae *et al.* 1989). Some respondents from central government agencies were concerned about the difficulty of ensuring consistency between regional monitoring methodologies and policies along with the devolution of resource management decision-making to regional government.

Following this survey, a questionnaire was sent to central government agencies and catchment authorities in July 1989 to obtain an overview of current environmental monitoring in this country. Questions covered the type of data collected, the use of the data, the resources used in monitoring and the effect of government restructuring on monitoring. The responses were collated and analysed by Steven (1990) and showed that because of reorganisation of central government agencies there has been a marked shift towards short-term client-oriented work at the expense of long-term monitoring programmes. In those agencies surveyed, there was minimal focus on human impacts on the environment and also on how environmental changes affect human wellbeing, although the latter may have been due to the fact that the agencies surveyed did not have direct responsibility for monitoring human wellbeing. Respondents provided very little information on monitoring to assess the effectiveness of management strategies for the achievement of quality or compliance although this type of performance monitoring was not specified in the questionnaire.

4. Environmental indicators

Monitoring involves the repeated measurement of particular environmental attributes such as temperature, pH, rainfall, plant density, animal numbers etc. From these environmental variables, indicators may be selected that inform us about the state of the environment omitting the need to peruse all the environmental variables that have been measured.

These indicators may be physical, chemical or biological variables e.g. temperature, dissolved oxygen, periphyton biomass, or they may be indices which are some computed function of variables e.g. dissolved oxygen saturation, periphyton “nuisance level”. They may apply at various levels such as the biochemical and species level or the ecosystem or community level.

Indicators may:

- * be predictive e.g. water levels in surface and groundwater reservoirs can be used to predict future water shortages.
- * be descriptive e.g. levels of pesticides and their degradation products per unit area of agricultural land.
- * show trends e.g. change in species diversity over time.
- * provide a measure of environmental response e.g. improved pasture production as a result of pest control.

Since the environment is a complex mosaic of interrelated components, no single indicator can fully describe the state of the environment and how it is changing. A series of carefully selected indicators is required to provide a profile of the overall state of the environment (Gelinis and Slaats 1989).

The choice of appropriate indicators must be related to the problem or objectives of the study. When concerned with management of the environment the indicators will need to reflect the objectives of management. Rapport (1987) recalls the three “R’s” of all well chosen environmental indicators: Relevance, Reliability and Robustness.

Environmental indicators have been developed by Vos *et al.* (1986) to have social, planning and communication functions so that “they enhance the appreciation of the social significance of a cleaner environment” and “express the benefits of the environmental policy in socially accessible terms”.

4.1 *Criteria for choosing appropriate environmental indicators*

The following criteria for indicators have been selected from several sources (e.g Elkin 1987, Friend 1989, Gelinas and Slaats 1989, Liverman *et al.* 1988, MacRae 1988, Richardson in Bernard 1987, Vos *et al.* 1985).

Indicators should:

- * be capable of identifying changes in environmental conditions (quantity and quality) and the agents of these changes.
- * be understandable to the general public and decision makers as well as to scientists.
- * be limited in number if they are to be useful to decision makers.
- * be scientifically based and valid. Methods chosen can influence the accuracy and credibility of an indicator. Technology should be used which has an accuracy that relates to the objectives of the monitoring programme. The understanding upon which the indicators are based must be accurate and scientifically defensible.
- * be sensitive to change in space and time. Indicators should be geographically referenced, where possible, to allow spacial patterns and trends to be identified. Sampling interval should be sufficiently frequent and length of the programme sufficiently long to detect trends. Indicator monitoring over time may be used to develop predictive models.
- * be based on relative ease of data collection and, where possible, be based on existing data collection, storage, retrieval and interpretation programmes. However, it is important that the use of existing data is subject to the appropriate quality assurance procedures.

- * provide early warning of environmental damage. It is increasingly recognised that certain species, particularly those near the top of the food chain eg. trout, are sensitive to a wide range of stresses and are therefore good indicators of deteriorating environmental conditions. In addition, indicators at higher levels of ecological organisation, such as at the level of populations or communities, reflect stresses and effects that occurred in the past at lower levels, such as at the biochemical or species level. By selecting environmental indicators at lower levels, it may be possible to anticipate what might happen at higher levels in the future if ameliorative steps are not taken.

Indices may provide useful information but there are limitations to the approach because of the pooling or weighting of diverse data and caution is needed in their use and interpretation (Gelinas and Slaats 1989). Some indices tell us very little and useful information may be lost (Smith 1989) or they may give little understanding of the reason for change in some aspect of environmental quality or of what may happen in the future (Bernard 1987). Smith (1986) has developed water quality indices for use in New Zealand as a management tool to present information to non-scientists in a simple form for uses such as inter-site comparisons and trend assessments.

4.2 *Indicators in State of the Environment reporting*

Indicators are frequently used in SERs. They are continually being developed and updated by several countries and international agencies. They include environmental indicators as discussed above and may also include social indicators, indicators of sustainability, policy indicators etc.

It appears that 1990 will see the development of indicators suitable for an SER by both Canada and The Netherlands. Environment Canada is to set up a task force of about 20 people to develop a preliminary set of key indicators for Canada this year (T. MacRae, Environment Canada, pers. comm.). In the Netherlands, the Institute for Environmental Studies, Free University of Amsterdam will coordinate indicator development and take responsibility for developing pollution and natural resource indicators. Ecology indicators will be a cooperative effort between the Ministry of Public Works and the Centre for Environmental Studies at the University of Leiden (A. Gilbert, Institute for Environmental Studies, Amsterdam, pers. comm.).

An indicator for an SER has been defined by Stokes and Pierarz (1987) as:

a measure of the welfare of the system under study.

For example, measures of productivity and soil nutrient status are SER indicators for forest systems (Stokes and Piekarz 1987).

A truly comprehensive set of indicators for an SER would not only describe environmental conditions (quantitative and qualitative) but also the causes of environmental change (human and natural processes). The resultant understanding of trends in environmental conditions is needed to anticipate change rather than respond to observed change (Gelinis and Slaats 1989). In fact one of the criticisms of many SERs is that, at best, they are only recording damage long after it has occurred.

The development of meaningful indicators for an SER requires the identification of clear, precise objectives by the agency responsible for the management of the resource. If the indicators are not related to the agency outcomes, they will not be used (Goldberg 1990). Environmental quality objectives and indicators need to be regularly reviewed by management agencies and scientists to ensure that they remain appropriate since the condition of the environment, community aspirations and hence government policy are all subject to change. A longer term objective for SERs is to identify data gaps. The survey of government agencies involved in environmental monitoring (Stevens 1990) gave us an indication of where these gaps might be (Section 3).

5. Frameworks for State of the Environment reporting

In order to develop useful indicators for an SER, some type of framework is needed to organise the information that is collected according to the required objectives. This section briefly examines some of the frameworks that have been used for SERs.

National SERs have been produced by most developed countries and have the potential to provide environmental information to a wide audience, including decision makers, so that management objectives can be assessed for their success or failure. SERs can be organised to present data on conditions and trends for environmental media and resources, to highlight particular issues, or to emphasise environmental processes by describing relationships between socio-economic and ecological systems (Sheehy 1989). Data collections exist for the management of resources and regulation of resource use and they may not be easily adapted to the production of an SER. Any framework used for an SER must accommodate the objective of describing complex natural systems and the use of existing information networks, provided these are of an appropriate quality.

Sheehy (1989) compares and discusses the organisational and spatial frameworks that have been used for SERs. The choice depends on the purpose for which the report is being produced, the effective use of available data, the intended audience and the budget.

The **spatial** frameworks identified by Sheehy are:

Jurisdictional or administrative	Information presented for geographical units based on jurisdictional or administrative boundaries. Most SERs produced by government agencies or international organisations are of this type e.g. OECD international reports of questionnaires.
Environmental component	Information presented for geographical units determined by particular environmental factors e.g. watersheds, vegetation or climatic zones. Used in the Canadian SER where data for ecosystem framework were not available (Bird and Rapport 1986).
Ecosystem	Information presented for geographical units which contain distinctive sets of abiotic and biotic features that are ecologically inter-related. Used in the Canadian SER (Bird and Rapport 1986). The New Zealand ecological districts would fit into this framework.

Combination approach Comprehensive SERs often use more than one spatial framework e.g. in Australia's SER (Department of Arts, Heritage and Environment 1985) jurisdictional and environmental boundaries are combined to develop a map showing the distribution of groundwater problems.

The **organisational** frameworks identified by Sheehy are:

Issues framework	selects and reports on environmental problems.
Resource sector	reports on conditions and trends of natural resources e.g. forestry, fisheries, agriculture.
Environmental media	describes the state of the environmental media e.g. air, water, land.
Environmental process	reflects the dynamic nature of ecosystems in a stress-environmental response approach.
Combination framework	where more than one organisational framework is used in an SER.

Some national and global SERs use one of more of these frameworks. Examples are given below of the environmental process/stress-response framework and combination frameworks that also use the stress-response approach.

The environmental process or stress-response framework (Table 5.1) was developed by Rapport and Friend (1979) and used in the Canadian SER (Bird and Rapport 1986) and in the Statistical Compendium (Statistics Canada 1986). It provides an alternative to more traditional methods of organising environmental statistics as it distinguishes between indicators reflecting agents of environmental change (stress) and indicators of environmental conditions (response to the stress), thus allowing an understanding of why environmental changes are occurring. Agents of change may be natural processes (e.g. major climatic events) or humans and their activities (harvesting, waste generation etc.) while responses may be quantitative (e.g. forests, fisheries, non-renewable resources) or qualitative (air, water, food, human health etc.).

The framework therefore illustrates ecosystem dynamics and demonstrates temporal and spatial associations for a knowledgeable audience. It has the advantage of facilitating the development and evaluation of management responses to environmental problems.

However, Sheehy (1989) warns that this approach may be limited by available data and therefore may require a large financial commitment to an SER.

The Regional State of the Environment Report for Waterloo, Canada (Elkin 1987), uses a **combination approach** and has applied the stress-response framework to an urban ecosystem which has both spatial and system properties. Spatially the urban area is divided into built city, urban fringe and urban shadow. Structurally the urban ecosystem is divided into abiotic (water, minerals, air, noise etc.), biotic (agriculture, forestry, wildlife) and cultural (demographics, economics, public health, land use etc.) subsystems. Each environmental component in the subsystems influences the others and each component is analysed individually and for its effect on the others and therefore on the whole ecosystem.

The Organisation for Economic Cooperation and Development (OECD) produced a framework of environmental statistics for the organisation of environmental data (OECD 1985). Here again human activities of energy, transport, industry and agriculture create "pressure" on the environment to which economic and environmental agents "respond" (Figure 5.1). In the report, the environment is divided into air, water, land, living resources, solid waste and noise.

Table 5.1: Organisational framework - STRESS. (Source: Statistics Canada 1986).

Stressor categories	Activity categories	Activity statistics ¹	Environmental stress statistics ¹	Environmental response statistics ¹	Human response statistics ¹
Natural source stresses	Geophysical and meteorological events and processes	Floods, storms, earthquakes	Rates of erosion, landscape change	Changes in air, water, soil characteristics Changes in biotic state	Environmental restructuring
Harvesting	Agriculture Forestry Fisheries	Production	Changes in soil characteristics Depletion of stocks	Changes in biotic state including population size, regenerative capability	Conservation Changes in methods of farming, harvesting Legislation, fish quotas
Extraction and depletion of non-renewable resources	Metals and non-metallic minerals Fossil fuels	Extraction	Depletion of resources Substitution	Substitution for scarce resources leads to impacts indirectly from wastes and restructuring associated with use of substitutes	Conservation
Environmental restructuring	Land conversion Restructuring water systems Transport networks Resource development	Construction of homes, dams, reservoirs, railways, highways Exploration for resources	Land converted, changed in character	Changes in air, water, soil characteristics (quality) Changes in biotic state including species diversity, population size (due to habitat change)	Changes in rate and location of land conversions Land use legislation Park creation
Generation of waste residuals	Mining Manufacturing Energy generation Transportation Households	Production Consumption Vehicle movements	Waste generated Emissions of wastes to air, water, soil; Disposal of toxins	Changes in air, water, soil characteristics (quality) Changes in biotic state including species diversity, population size Human health effects	Pollution abatement through process change, activity termination Legislation Conservation
Population (a background influence)	Population dynamics	Population growth, migration			Population control, resettlement

¹ Examples of kinds of statistics in this category

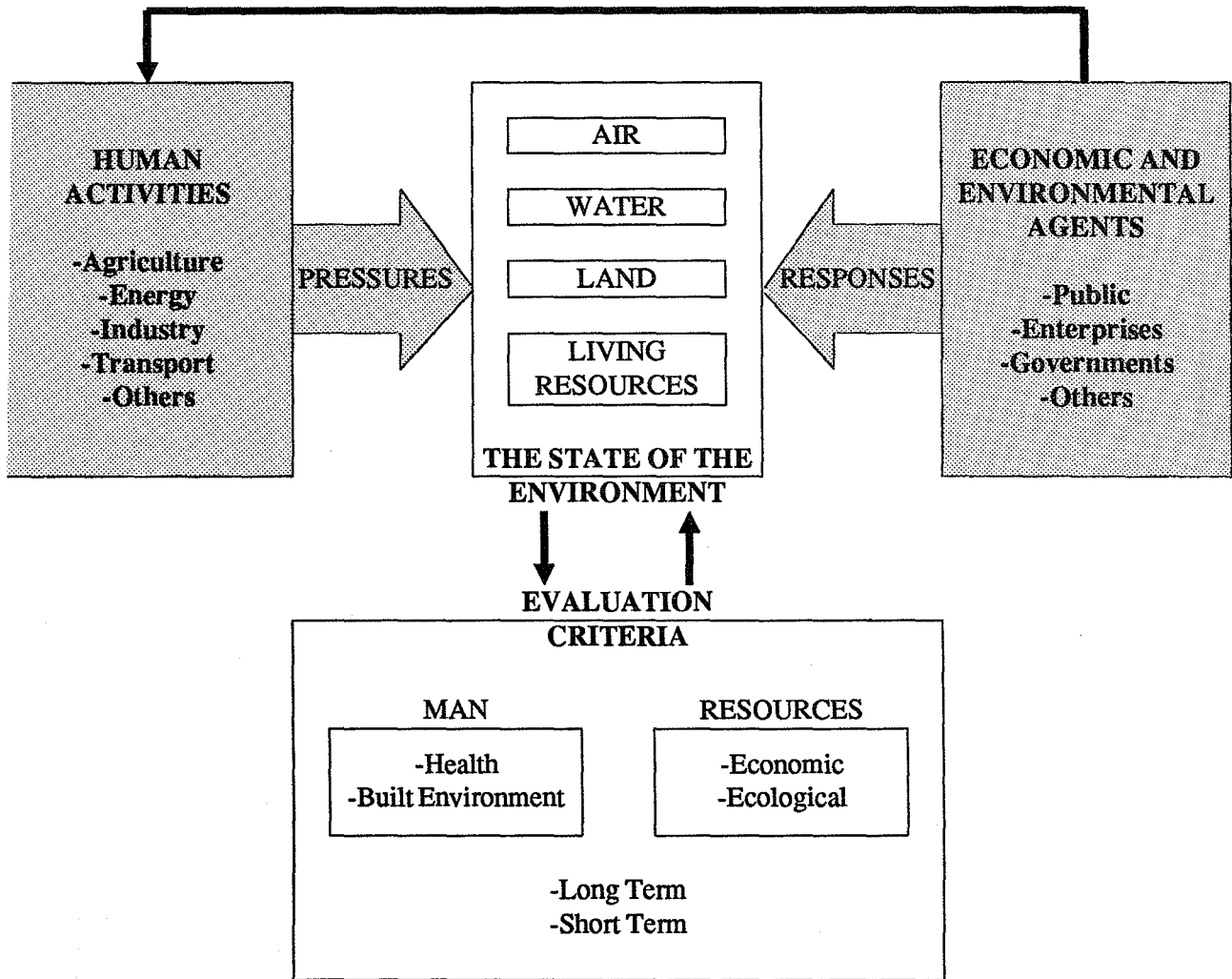


Figure 5.1: OECD framework (Source: OECD 1985)

Another related framework was developed in 1984 under the guidance of the Statistical Commission of the United Nations. Known as a **Framework for the Development of Environment Statistics (FDES)**, it aims to provide methodological guidance for the establishment of environmental statistics at the national level. FDES (Table 5.2) is designed to review environmental problems and determine their quantifiable aspects; identify variables for statistical descriptions; assess data requirements, sources and availability; and structure data bases, information systems and statistical publications (Friend 1989).

As with the stress-response framework, FDES reflects the effect of human activities and natural events on the environment which provokes human responses. Although the framework is arranged differently, the contents of the boxes are similar to the stress-response framework but the arrangement perhaps allows the cells to be expanded more easily. The FDES framework has an additional column (D) which provides “benchmark” data and illustrates links with other subject areas for possible further statistical analysis.

Table 5.2 Framework for the Development of Environment Statistics (Source: Friend 1989).

	Information components			
	A	B	C	D
Components of the environment	Social and economic activities, natural events	Environmental impacts	Response to environmental change	Stocks, inventories and background conditions
Flora				
Fauna				
Atmosphere				
Hydrosphere: freshwater marine				
Lithosphere: surface subsurface				
Human settlements				

The **Australian Environmental Statistics Project (AESOP)** framework is basically similar to the Canadian stress-response approach but incorporates four major features (MacRae 1988):

- * the integration of key data on levels of economic activity with environmental data,
- * an insight into the broad inter-relationships between the economy, industry and the environment,
- * avoidance of simple cause-effect relationships between specific forms of economic activity and specific aspects of environmental quality,
- * where practical, compatibility with existing Australian statistical series.

The AESOP framework for an SER has three parts:

- * human activity and the environment - an account of the pressures on the environment generated by economic, domestic and recreational activity,
- * the condition of the natural environment,
- * institutional responses - analysis of government and community perceptions of the environment and the need for environmental management and controls; the effectiveness of legislative and administrative processes established for management and control.

Dickenson (1988) considers that since New Zealand is a relatively small country, it may have to settle for a number of specialised lower cost systems of information with only summary information being brought together into a co-ordinated set of statistics prior to any identification of environmental indicators. He suggests a simple conceptual framework for environmental information based on the work of Antony Friend in Canada and containing information on:

- * natural resources,
- * how primary industries transform, husband and protect natural resources for the present and future benefit of New Zealanders,
- * the human settlements of New Zealanders, from single dwellings on their own to whole cities, where consumption of resources occurs.

The **environmental process/stress-response framework** was considered a suitable starting point for our New Zealand study in 1989 since it provided the basis for several of the other frameworks.

However, some type of spatial framework will be required for a New Zealand SER so that information can be presented on a geographical basis. An appropriate framework would be the New Zealand ecological districts which form a local part of New Zealand where the topographical, geological, climatic, soil and biological features, including the broad cultural pattern, produce a characteristic landscape and range of biological communities (W.M. McEwen, Department of Conservation, pers. comm). Groups of adjacent ecological districts can be considered together as an ecological region.

6. Questionnaire on management objectives and indicators

Modifications were made to the stress-response framework for New Zealand conditions and examples of environmental quality objectives and indicators that might be applicable to SER were added from a review of the literature (see Appendix 1). Environmental indicators need to be based on the objectives of the agency concerned with management or they would not reflect whether the objectives are being fulfilled or are relevant. Therefore management agencies should be able to provide the best response to the call for suitable indicators.

In July 1989 a questionnaire was sent to central government agencies and catchment authorities to obtain an overview of current environmental monitoring in New Zealand (Part A) and to receive comments on the proposed framework and management objectives and indicators of environmental response to stress (Part B). The responses to Part A were collated by Steven (1990) as discussed in Section 3..

About half (18) of the 35 replies to the questionnaire included comments on Part B on objectives and indicators for an SER (see Appendix 2 for list of responding agencies). Some of these were very constructive and the ideas were incorporated into the examples of management objectives and environmental indicators that could be used for an SER in New Zealand.

7. Management objectives and indicators of environmental response to stress

A review of overseas literature, along with the responses to the questionnaire, provided examples of management objectives and indicators of environmental response to stress that could be appropriate for an SER. New Zealand examples are shown in the following pages.

The agency responsible for management is suggested at the end of each section. DSIR objectives are not directly related to environmental management and thus indicators cannot be tied in with the objectives of this agency so it is not included in these tables. However, DSIR performs a most important role in environmental monitoring by providing background data on environmental change due to natural causes or human activities. For example, the Water Resources Survey (Division of Water Sciences) collects basic data on river flow, lake level, river cross-section, rainfall intensity, river sediment load, and river and lake water quality and biota (M.P.Mosley, pers. comm.). The National Water Quality Network (Division of Water Sciences) covers determinands such as pH, conductivity, dissolved oxygen, visual clarity, turbidity etc. (Smith *et al.* 1989). Seismic monitoring is carried out by DSIR Geology and Geophysics Division. In addition, the NZ Meteorological Service undertakes climatic monitoring which is used by both monitoring and management agencies.

Table 7.1 Form of stress

NATURAL

Activity creating stress		climate regime, tectonic processes, landform instability
Objectives	*	recognise ecological integrity of natural ecosystems
	*	preserve representative habitats
	*	establish a network of Protected Natural Areas representing full range of natural diversity in New Zealand
Indicators	*	change in numbers and diversity of plant and animal species and populations due to natural environmental change
	*	change in representative habitats and ecosystems
	*	numbers and diversity of lizards as indicators of habitat destruction and introduction of exotic predators on islands, and of past land use practices and intensity of rabbit control in tussocklands
Objective Indicator	*	maintain species diversity
	*	number of native species known to be extinct : number of species at risk
Objective Indicator	*	identify and eliminate unwanted introduced plant and animal species
	*	number of unwanted species introduced : eliminated
Objective	*	manage quality and quantity of freshwater systems to set standards
Indicators	*	changes in river flows, lake levels, river cross-sections, river sediment load, rainfall intensity, water quality due to natural causes
	*	change in depth of submerged plant growth
	*	change in periphyton species and abundance
Objective Indicator	*	maintain nation-wide information on fish populations
	*	nation-wide distribution patterns of fish species
Responsibility		DOC, MAFTech, MAFFish, regional and local authorities
Objective Indicator	*	avoid or mitigate risk by controlling land use and type of construction
	*	degree to which local governments have identified risk zones in their territory and are actively applying commensurate building controls
Responsibility		local and regional authorities

Table 7.2

Form of stress

POPULATION

Activity creating stress		demographic changes
Objective	*	control location of population to avoid or mitigate risk
Indicator	*	incidence of past earthquakes, eruptions, earth deformation, stress buildup, active deformation
Objective	*	limit urban sprawl according to regional policy
Indicator	*	area of urban land development/ unit land area
Objective	*	maintain population health
Indicators	*	incidence of infectious diseases
	*	per cent compliance with health standards by water supply authorities
	*	incidence of contamination of source water
Objectives	*	manage leisure activities to minimise impact on environment
	*	minimise environmental effects of tourism
Indicators	*	change in demand on natural resources/ unit area
	*	spread of noise and pollution over time and space
Responsibility		regional and local authorities, DOC, Dept Health, Dept Tourism

Table 7.3 Form of stress**HARVESTING**

Activity creating stress	agriculture, horticulture, forestry, fisheries, aquaculture
Overall objective	manage for sustainable use
	Agriculture and horticulture
Objective	* produce quality plant and animal products that meet required standards
Indicators	* change in levels of production/ unit area in type of use * change in quality of product
Objective	* maintain soil quality
Indicators	* change in soil structure, organic matter, nutrient content and biota/ unit area in type of use * erosion estimates by wind and/or water/ unit susceptible area * soil acidification/ unit area in type of land use * soil salinity/ unit area in type of land use * change in bulk density/ unit area in type of land use
Objective	* increase species diversity
Indicator	* number of species and varieties under cultivation/ unit time
Objective	* control disease and nuisance species according to regulations
Indicators	* change in area occupied by nuisance species * incidence of disease/ unit area/ species
Objective	* maintain soil, air and water quality to set standards
Indicators	Soil * level of phosphates, copper (pig slurry), heavy metals and contaminants (sewage sludge and compost)/ unit area of this type of land use * levels of pesticides and their degradation products/ unit area of agricultural and horticultural land Ground water * level of ground water table/ area water withdrawn for agricultural purposes * loss of water quality (leaching of nitrate, mobile pesticide residues and degradation products)/ area agricultural or horticultural land use

Surface water

- * levels of siltation and suspended sediment/ area agricultural or horticultural land
- * runoff, leaching or direct discharge of fertiliser, organic matter, pesticide residues and degradation products/ unit area in type of land use

Flora and fauna

- * loss of species/ unit land area in type of use
- * loss of ecosystems/ unit land area in type of use
- * loss of ecological diversity/ unit land area
- * change in composition of soil microflora/ unit area in type of use
- * area affected by eutrophication (excess plant growth, oxygen depletion)/ unit area of agricultural or horticultural land
- * effects of pesticides on soil microflora, weed resistance, animal poisoning and resistance/ unit area in type of use

Other

- * unacceptable: smell (combustion gases, manure, ammonia, pesticides)
 - noise
 - residues
 - spray drift
 - dust
 - smoke and particulates from controlled burning
 - aesthetic impacts

Responsibility MAFTech, DOC, regional and local authorities

Forestry

Overall objective manage forests for sustainable use

Indicator * extent of use of unsustainable practices, such as windrowing which displaces soil organic matter, against overall management strategy

Objectives * maintain site quality

Indicators *

- * changes in soil organic matter and nutrient dynamics/ unit area
- * changes in soil animals/ unit area
- * changes in growth of key tree species/ unit area
- * changes in vegetation biomass/leaf area relative to sapwood area
- * changes in wildlife diversity/ unit area
- * increased wind and water erosion/ unit area

Objective * maintain forest health by reducing disease and nuisance species to acceptable levels

Indicators *

- * area occupied by nuisance species
- * incidence of disease/ unit area

Responsibility Ministry of Forestry

Objective	*	maintain water quality to required standards
Indicators	*	changes in ratio of stream flow: rainfall
	*	change in levels of suspended sediment/ unit area of forestry
	*	amount of siltation in relation to stream flow and forestry activities
	*	levels of runoff/ unit area forest
	*	area of fresh water habitat/ area under forestry
	*	unacceptable runoff or leaching of fertiliser, pesticide residues and degradation products/ unit area of forest
Responsibility		Ministry of Forestry, regional and local authorities

Fisheries and Aquaculture

Objective	*	minimise the effect of natural disasters
Indicator	*	change in fish populations and/or spawning area/ area of catchment or region
Objective	*	maintain fish habitat
Indicators	*	deterioration of physical habitat/ unit area of habitat
	*	size of fish population(s)/ unit area
	*	density of benthos/ unit area of habitat
Objective	*	national assessment of amount and type of recreational and commercial fishing
Indicator	*	changes in recreational and commercial harvest and effort
Objectives	*	maintain water quality in fish and shellfish farms to set standards
	*	ensure absence of disease in fish and shellfish farms
Indicators	*	incidence of pollution and disease/ unit area
	*	unacceptable oxygen levels/ unit time/ unit area
	*	contaminant levels/ unit time/ unit area e.g. pH decline
	*	frequency of tumours or lesions in aquatic organisms e.g. abnormalities in chironomids
	*	bioaccumulation of chemicals e.g. PCB's, DDT, Hg, in birds and fish
Objective	*	protect trout and whitebait spawning areas
Indicator	*	area of spawning habitat destroyed/ catchment or river system
Responsibility		MAFFish

Table 7.4 Form of stress **USE OF RENEWABLE ENERGY RESOURCES**

Activity creating stress		hydro, geothermal, wind, biomass
Objective	*	maintain level of use, location and extent of use to conform with requirements
Indicators	*	incidence of erosion, landslides, water level fluctuations due to use of renewable energy resources
Objective	*	maintain air and water quality to meet set standards
Indicators	*	frequency of air pollution from geothermal and biomass combustion that exceeds standards
	*	frequency of water pollution from hydro, geothermal and biomass conversion that exceeds standards
	*	incidence of deleterious effects of waste heat on aquatic ecosystems
	*	incidence of changes in water quality that exceed standards/ unit area
Objective	*	minimise landscape change
Indicators	*	changes/ unit area in vegetation including submerged plants
	*	changes/ unit area in wildlife habitat including access for fish migration
Responsibility		Electricorp, MAFTech, MAFFish, regional and local authorities

Table 7.5 Form of stress **EXTRACTION & DEPLETION
OF NON-RENEWABLE RESOURCES**

Activity creating stress		mining, fossil fuels
Objective	*	manage for sustainable use
Indicators	*	indicators of resource depletion
	*	indicators of change to the use of substitutes
Objective	*	minimise landscape change and erosion
Indicator	*	area involved in landscape change and erosion/ unit area of resource extraction
Objective	*	rehabilitate land to meet requirements
Indicator	*	percent mined areas rehabilitated
Objective	*	minimise impact on downstream water quality
Indicator	*	change in water quality variables e.g. sediment loading, oxygen
Responsibility		regional and local authorities

Table 7.6

Form of stress

ENVIRONMENTAL MODIFICATION

Activity creating stress		land conversion, transport networks
Objectives	* * *	minimise environmental impact minimise rate of land conversion convert land to set requirements
Indicators	* * *	environmental impact to meet standards number of days/ year noise and vibration exceeds acceptable limits area of land converted/ year
Objectives	* *	protect from modification reserves representative of ecosystems, ecological communities and habitats maintain freshwater systems to required standards of quality and quantity
Indicators	* * *	number and extent of unmodified reserves representative of ecosystems, communities and habitats change in natural aquatic and terrestrial habitat and local climate due to modification of land and water systems change in species diversity
Responsibility		regional and local authorities, DOC

Table 7.7

Form of stress

WASTE GENERATION

Activity creating stress	mining, manufacturing, energy generation, transportation, households
Objectives	<ul style="list-style-type: none"> * maintain environmental health and aesthetics * minimise amount of waste generated * increase amount of recycled waste
Indicators	<ul style="list-style-type: none"> * incidence of contaminant poisoning * percent waste materials recycled per year from paper and cardboard, glass, all metals, aluminium, other non-ferrous metals (Cu,Pb,Zn,Ni,tin), plastics
Objective	<ul style="list-style-type: none"> * treat waste generated to meet set standards * manage emissions into air, soil and water to meet set standards * manage quality of air, soil and water to meet set standards
Indicators	<ul style="list-style-type: none"> * no. cases of inadequate disposal/year * incidence of heavy metal contamination * Pb-emissions by traffic/ unit area * Pb-content in blood of children/ unit area * no. days/ year levels SO_x, NO_x, CO, CO₂, HC, trace elements, particulates, radionuclides exceed international safety limits * changes in water quality e.g.from mine drainage, storage heaps, oil spills * water pollution from surface runoff * incidence of heavy metal pollutants exceeding recommended levels of use * incidence of bacterial contamination of water and aquatic organisms exceeding "safe" levels * incidence of deleterious effects of waste heat * incidence of fish kills
Objective	<ul style="list-style-type: none"> * maintain radiation monitoring to ensure information continuously available to allow appropriate decisions
Indicators	<ul style="list-style-type: none"> * frequency with which levels of radioactivity in environment exceed "internationally acceptable" * effectiveness of control measures instituted if needed
Objective	<ul style="list-style-type: none"> * minimise noise
Indicators	<ul style="list-style-type: none"> * no. cases/ year of excess noise from road, rail and air traffic, and from industry * no. persons reporting serious or some noise nuisance/ year * no. houses situated with noise level above standard for road and aircraft noise
Objective	<ul style="list-style-type: none"> * minimise unacceptable smells
Indicator	<ul style="list-style-type: none"> * no. dwellings/ year affected by malodour
Objective	<ul style="list-style-type: none"> * enforce reclamation of mined areas
Indicator	<ul style="list-style-type: none"> * number of prospecting/mining licences issued/ unit area vs mined areas reclaimed
Responsibility	regional and local authorities, Dept Health including Radiation Laboratory, Coalcorp, Electricorp, MAFFish, MAFTech, MAFQual

8. Indicators related to agency outcomes

The management objectives listed in Section 7 are very similar to the environmental “outcomes” of some central government agencies. The difficulty of the approach used in Section 7 was to distinguish who had responsibility for each of the management objectives. This difficulty could be overcome by focusing on the objectives of each management agency. Since some agencies have related objectives, environmental indicators that reflect these objectives may also be related.

In order to focus on specific agencies, an attempt was made to relate their outcome statements, as listed in the corporate plans, to environmental indicators as listed in Section 7. This exercise was undertaken by the Ministry for the Environment where the Ministry’s outcomes were grouped in terms of “environmental quality”, “sustainable development”, “good decision-making processes” and “public environmental awareness and responsibility” (Goldberg 1990). For example:

Outcomes in environmental quality: terrestrial systems

“Outcome	Good land and landscape management including sustainable agricultural and forestry practices and avoidance of land degradation e.g. soil erosion
Outcome measurements	trends in total surface area of bare, eroded land trends in agricultural chemicals residue concentration in soil and water changes in soil organic matter and nutrient content changes in soil animals”

The outcome statements of some government agencies do not adapt easily to the outcome-indicator format. Examples of where environmental indicators could be used for stated outcomes are given here:

MINISTRY OF FORESTRY

Outcomes from Corporate Plan 1989/90; suggested indicators from Section 7.

Outcome	To provide a sustainable wildland asset
Indicator	the extent of use of unsustainable practices against overall management strategy
Outcome	To provide a healthy, profitable and sustainable forestry sector
Indicators	area occupied by nuisance species incidence of disease indicators of “profitability”, “sustainability”

MINISTRY OF AGRICULTURE AND FISHERIES

Outcomes from Corporate Plan 1989/90; suggested indicators from Section 7.

Outcome Innovative and profitable primary industries, set up on the basis of sustainable and efficient production of quality products which are internationally competitive

Indicators change in levels of production/ unit area in type of use
change in quality of product/ unit area in type of use

Outcome Preservation of New Zealand's environment and its international standing as free from disease, pests and residues in animals, plants, fish and foods

Indicators incidence of disease and pollution
area occupied by nuisance species
indicators of soil, air and water quality to meet set standards

The reason for the difficulty in this exercise is because the outcomes stated in some corporate plans are not clear management objectives. The objectives and indicators listed in Section 7 relate to monitoring the state of the environment. If clear management objectives are stated, indicators can be selected to tell us whether the agency is achieving its objectives.

For State of the Environment reporting, it would be useful for those agencies with environmental management responsibilities to have the agency's management objectives along with carefully selected environmental indicators stated in the corporate plan.

9. Extending the State of the Environment reporting process

State of the Environment reporting goes beyond identifying indicators of the state of the environment. An understanding of environmental processes is necessary to evaluate the appropriateness of existing policies, programmes and management practices and to implement remedial action to manage environmental resources effectively.

“State of the Environment reports have had limited success in providing information on the **significance** of ecological change to which thresholds have been crossed, and the nature of managerial intervention to be recommended. Until this is accomplished (there is) little prospect for State of the Environment reports to become useful to government and corporate decision makers” (Stokes and Piekarz 1987).

State of the Environment Reports are not yet given the same status as economic and social reports. One reason for this is the lack of adequate dialogue between physical and social scientists. Another reason is the lack of data to provide reliable statistical analyses of environmental trends and spatial distributions. This is partly due to the dynamic character of environmental systems which make it difficult to distinguish between basic changes in the state of the environment and unusual, but normal, natural fluctuations (Friend and Rapport 1989).

While SERs can serve to highlight problem areas, an understanding of how that state was obtained requires an evaluation of existing policies and management practices. Gelinas and Slaats (1989) have termed this the “value-added” of the SER process. The value-added of an SER should offer an evaluation of the seriousness and extent of environmental changes and effects as well as the potential for their control. A model of the value-added of the SER process is shown in Figure 9.1.

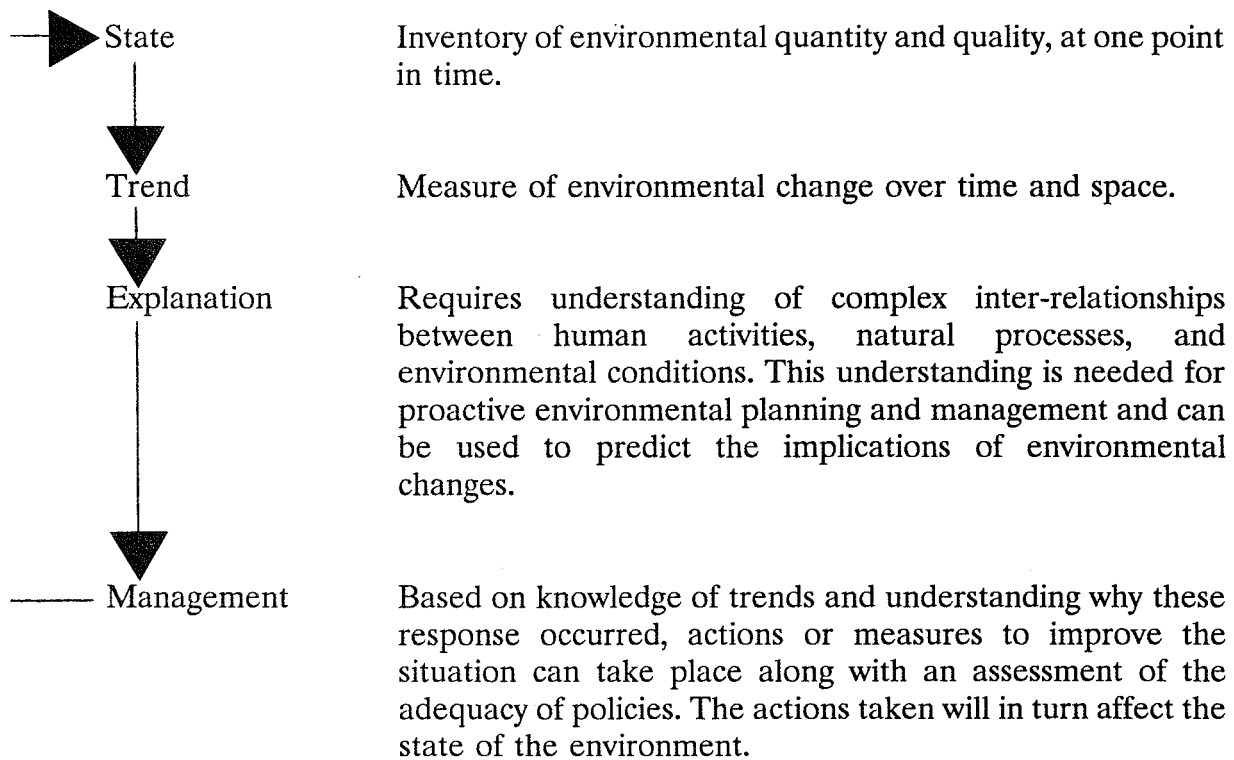


Figure 9.1: Model of the value-added of the SER process (after Gelinas and Slaats 1989).

Assessment of policy in an SER can take place in a number of ways. Examples are given below from the Netherlands, Norway and New Zealand.

8.1 Environmental trend indications

It may be assumed that the state of the environment is the result of a policy or management strategy implemented over a period of time but, while environmental indicators may reflect the results of the policy, they do not reflect the nature of policy and its changes (Vos *et al.* 1985). While it is unlikely that environmental and policy indicators could be presented as a single variable, Vos *et al.* (1985) suggest that by presenting both indicators together, the extent to which the environmental policy is related to environmental quality remains unspecified. Research would indicate whether it is relevant to put these particular indicators together. The combined trends in environmental quality and environmental policy are termed **environmental trend indications** and their value depends on the specification of environmental and policy indicators.

Examples of environmental trend indications from the Netherlands:

1. * Quantities of toxic substances discharged into the North Sea (Hg, Cd, PCB etc.)
* Concentrations of toxic substances in fish and shellfish
* Policy measures concerning these substances
2. * Species disappeared from the Netherlands
* Species at risk
* Re-introduction of species
3. * Emissions of lead by road traffic
* Lead concentration in blood of children and possible new standards
* Policy measures containing lead

The trends in this example are presented graphically (Figure 9.2) over a similar period and geographical area (Vos *et al.* 1985).

4. The effect of the Dutch Pollution of Surface Waters Act 1970, i.e. polluter pays, is illustrated (Figure 9.3) with index figures for the amount of industrial production and the oxygen-consuming pollution in industrial waste water (Bressers 1988). However, whether the reduced pollution is due solely to the change in policy or partly to other methods of waste disposal is not clear.

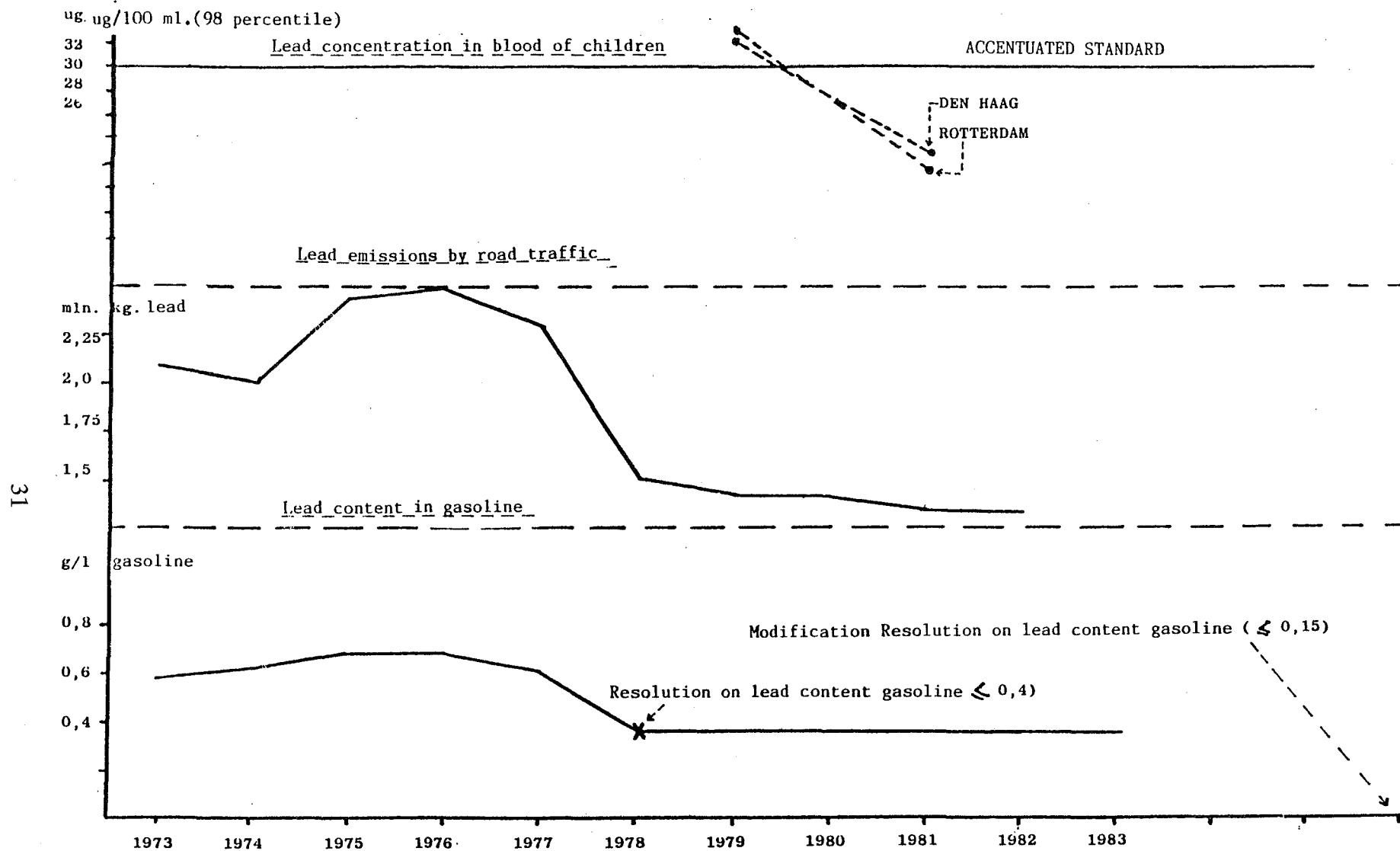


Figure 9.2: Lead in blood, lead emissions by road traffic and lead content in petrol, 1973-1983 (Vos *et al.* 1985).

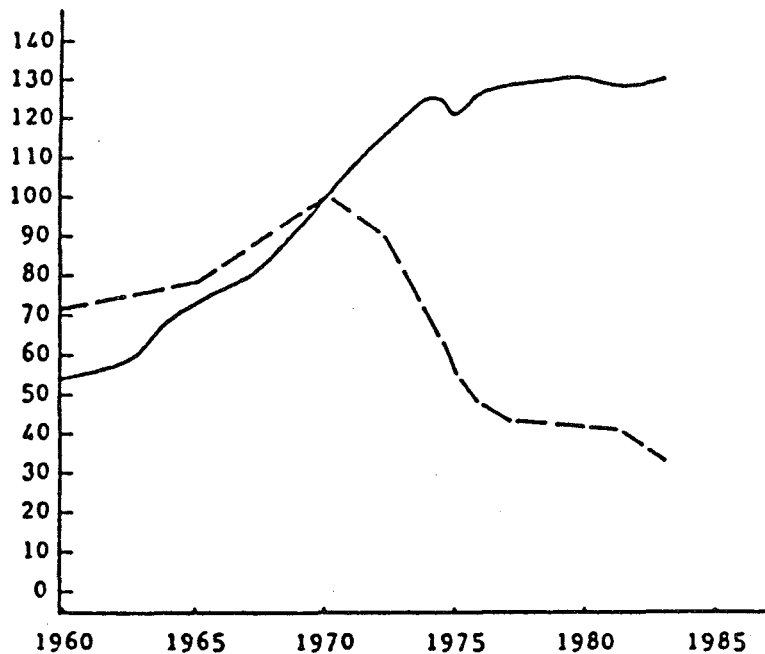


Figure 9.3: Index figures for the amount of industrial production (solid line) and oxygen-consuming industrial pollution in industrial waste water (dotted line). Polluter pays policy was introduced in 1970 (Source: Bressers 1988).

New Zealand examples

1. Inorganic lead levels in Auckland

Lead levels in airborne particulate matter have been monitored at four sites in Auckland since 1972. The Mount Albert site is residential, Penrose is industrial and Queen Street is an inner city, commercial site. Quarterly figures (Figure 9.4) show seasonal trends due to variations in meteorological conditions with higher levels occurring in the winter (Graham 1984, Narsey and Graham in prep.).

The decrease in lead levels from mid 1986 corresponds to the reduction in lead levels in 96 octane petrol from 0.84 to 0.45 g/l on 1 July 1986 and the introduction of lead-free regular grade petrol in January 1987. The lag effect may be due to lead sludge in storage tanks, urban dust on the side of the road etc. While the causal relationship appears clear, care needs to be taken in attributing all the reduction in air lead levels to the decreased lead in petrol because of annual fluctuations in air lead levels.

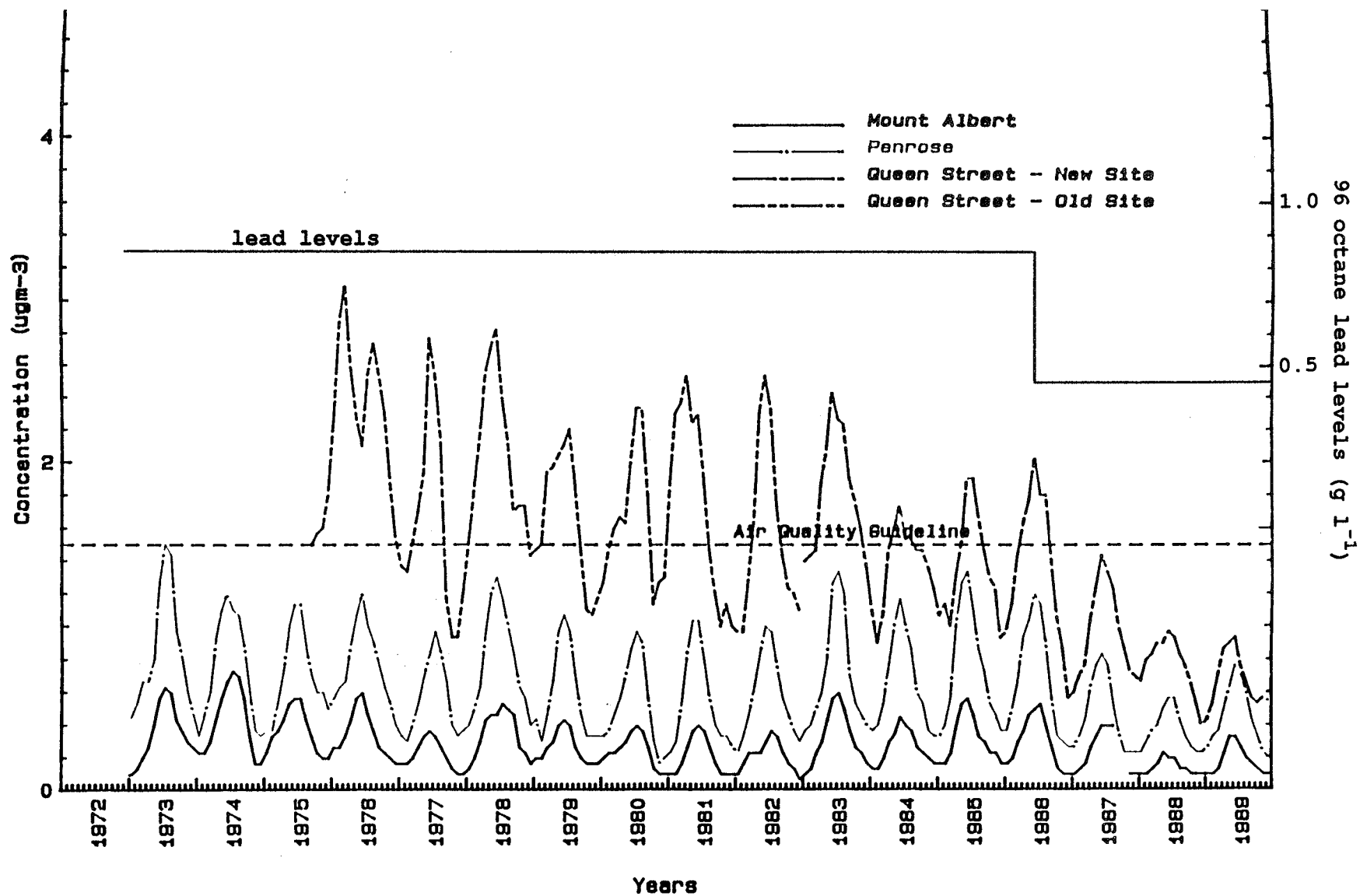


Figure 9.4: Quarterly moving averages of inorganic lead 1972-1989 (DSIR, NECAL Laboratory) and lead in 96 octane petrol.

2. Waihi-Temuka River pollution

This river system has eutrophication problems due to agricultural and urban development. Filamentous algal blooms occur in summer particularly when the low flows are depleted by water abstraction for rural water supply schemes and irrigation. Major point discharges are two woollscourers at Winchester and Temuka and two sewage treatment plants at Geraldine and Temuka.

In 1987 and 1988 discharges at the woollscourers were tightened up and sewage treatment was upgraded at Geraldine and Temuka. Figure 9.5 shows the improvement in the phosphate-phosphorus levels in the Waihi river above Temuka but little change in the water quality of the lower Temuka and Opihi rivers due to inadequate sewage treatment and other point source pollution. A new oxidation pond installation is now being monitored and tertiary wetland treatment areas are being recommended for major outfalls (Sevicke-Jones 1989).

9.2 Performance indicators

The SER process can provide us with environmental objectives and indicators of environmental response to stress and trends over time and space. How can an assessment of policy and management practices be incorporated into this process in New Zealand?

In Norway, environmental accountability has been introduced in response to the Brundtland report (J. Wright, Centre for Resource Management, pers. comm.). In their annual statement of intent every central government agency must discuss:

- * the environmental impacts of their policies
- * the environmental situation in their sector
- * the ameliorating measures they are taking

Government agencies in New Zealand must be accountable for their performance in environmental policy. Some government agencies list performance measures in their corporate plans to indicate the extent to which their policy outcomes have been fulfilled. For example, in the Department of Conservation corporate plan, although the objectives are not listed, each has a number of key outputs that are listed with specific activities to be undertaken to provide that output and the measures to be used to assess performance. Two examples are given below.

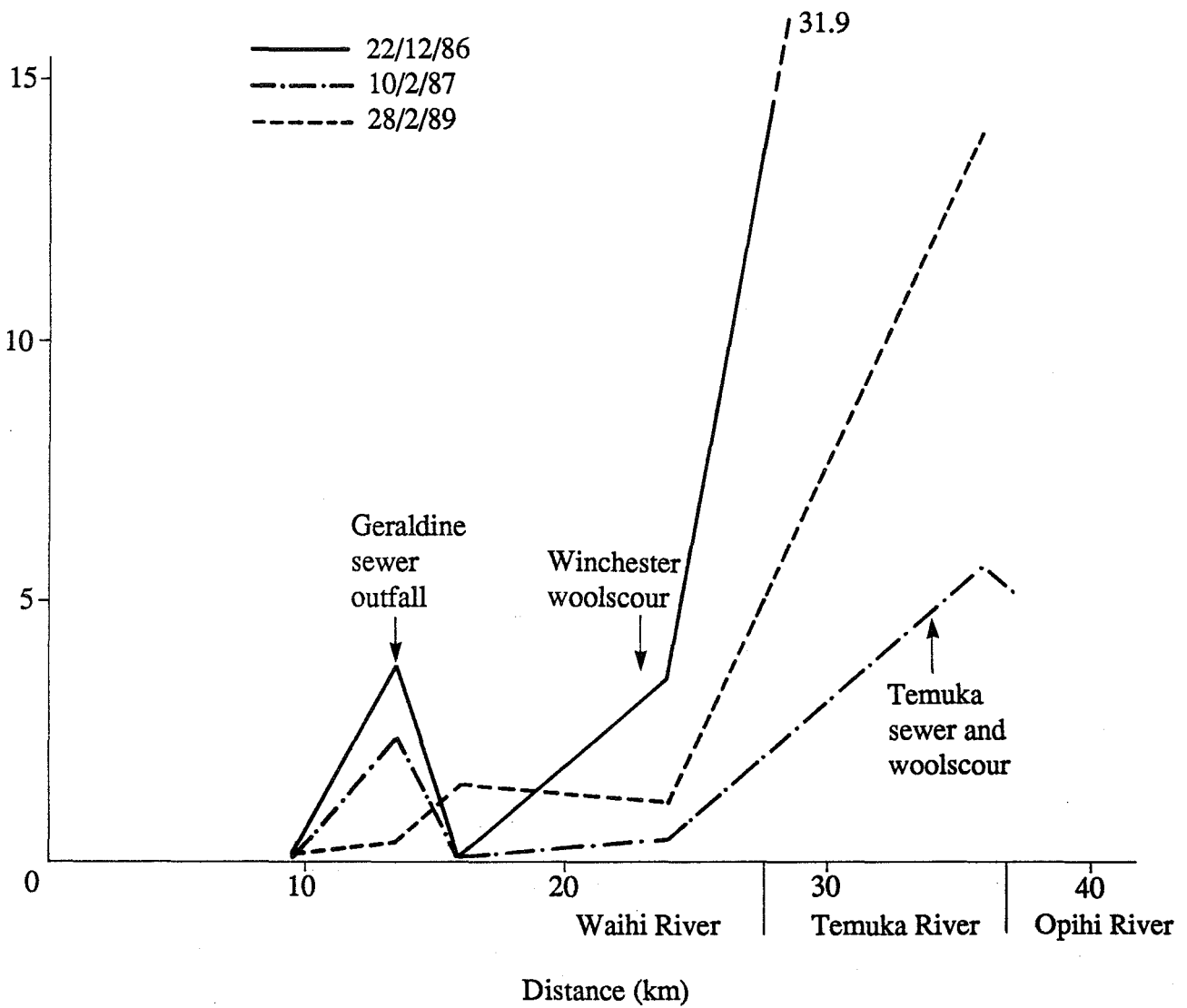


Figure 9.5: Phosphate-phosphorus loading of the Waihi-Temuka River system (South Canterbury Catchment Board data).

DEPARTMENT OF CONSERVATION

DOC Objectives (W.M. McEwen, DOC, pers. comm.); outputs, specific activities and performance indicators from Corporate Plan 1989/90.

Objective To ensure the survival of endangered, vulnerable, rare and other protected plants and animals and their habitats

Output Management services: protected species

Specific activities Management of endangered, vulnerable, rare and other at risk or protected species
Management of all ecosystems which have been declared protected or which are habitats of particular significance to survival of species

Performance indicators Number of distribution surveys undertaken
Number and success rate of species recovery, transfer/ introduction/ and captive breeding programmes undertaken
Number and success rate of marine mammal rescue operations undertaken

Objective To foster public recreation and to manage commercial recreation and tourism in areas administered by the Department

Output Provision of recreational services and licences

Specific activities Preparation of regional recreational and tourism strategies
Provision of recreation facilities and access
Provision of recreation opportunities through concessionaire
Administration or management of indigenous freshwater fisheries
Administration or management of freshwater sport fisheries and game animals
Marketing goods and services which promote conservation

Performance indicators Number of recreational facilities and access routes maintained to a satisfactory standard
Extent of visitor satisfaction with facilities and services provided, as measured by opinion surveys or qualitative judgement
Complete implementation of decisions from the review of fish and game quangos

If measures of performance were applied to environmental management objectives and listed in corporate plans, the SER process could serve to check environmental accountability.

10. Valued environmental components (vecs)

Management agencies and regional and local authorities need some indicators of public awareness and support for environmental matters so that they are in a better position to manage the environment on behalf of the people of New Zealand. The management objectives and indicators of environmental response to stress listed in Section 7 do not allow for the perceptions of the public, tangata whenua and special interest groups towards the environment.

Valued environmental components (vecs) are defined by Clark (1986) as “attributes of the environment that some party to the assessment believes to be important”. “Which environmental components are valued in a particular case will depend upon specific social, political and environmental circumstances as well as on the level of aggregation appropriate for the intended use. In general, policy makers, interest groups and scientists may all argue for inclusion of specific components”(Clark 1986). For example, Crutzen and Graedel (1986) have identified a list of valued atmospheric components, such as UV energy absorption, visibility degradation, material corrosion etc. The aim of management is to understand any relationships that may exist between these components of the atmosphere that are valued and the natural processes and human activities that might affect them.

The Ministry for the Environment (1990) sees vecs as the link between science and the lay perceptions of the environment. Using this view, how do we identify these valued components and how can they be passed on to management agencies and incorporated into a system of environmental monitoring/management?

Livesey (1988) suggests and discusses three views of the world held by New Zealanders that yield different values towards the environment: the anthropocentric view of the biological and physical world in which things are valued in terms of their contribution to human well-being; the view based on the belief that human activity should have as little impact on the natural world as possible; and a view in which people recognise a *wairua* (spirit) surrounding and embodied within the natural world and its components. These views are not exclusive or mutually incompatible; neither are they right nor wrong; but they serve to indicate the range of values held in New Zealand and therefore the range of vecs that can be anticipated.

Maori people value all aspects of the natural world with which they are kinsfolk. All forms of nature are sacred to different degrees and must be treated with respect. The

tangata whenua possessed intimate knowledge of those resources that were needed for survival. While there is no specific term in Maori for the word “value”, the idea is incorporated into the term *taonga* meaning a treasure or something precious. Marsden (1988) divides values into three levels related to the levels of the human personality: spiritual, psychological and biological. According to our definitions of vecs, the biological values concerned with material needs are relevant. However, it is easy to see that the concept of value is very broad and spiritual and social values intrude upon how all people perceive the environment.

The value assigned to an environmental component will vary according to its use or potential use, if any; the knowledge about the component; the cultural, educational and social background of the valuer; the surroundings etc. Attitudes towards an environmental component may change through time consequently affecting its value (Ward and Talbot 1988).

It may not be the resource that is valued but rather the quality of it that influences its value: what it looks like, how pleasant it is, how healthy, how safe, how accessible, whether it is suitable for recreation or as a food source.

Methods have been developed for evaluating the landscape and particular features in it but it must be recognised that some methods of evaluation are more appropriate than others in particular cases. For example, in assessing public preferences towards river scenery, Mosley (1989) found that the method which was suitable for assessing scenic attractiveness was less appropriate for assessing the suitability of the river for recreation. Information may be obtained from expert opinion, public responses to stimuli such as photographs or the experiences of those who interact with certain features of the landscape. Rather than this direct approach, we can try to understand vecs indirectly by observing peoples’ behaviour and attitudes towards the environment. For example, the indirect approach has been used by observing peoples’ attitudes towards water. In the studies conducted by the Water Quality Centre, DSIR, Hamilton, observation of recreationists’ behaviour at a number of North Island lakes has shown that, except for swimming, the intensity of water-based recreation was apparently not affected by the degraded or unattractive appearance of the water (Vant 1987).

The National River Angling Survey (Tierney 1988) showed that angling intensity was also not affected by unattractive conditions but the quality of angling was affected (Tierney 1987). The survey showed that if a river was highly valued many comments were made, mediocre rivers elicited almost no comment while rivers with water abstraction or water

quality problems elicited much negative comment (L.D. Tierney, MAFFish, pers. comm.). Popular rivers and highly valued rivers may not be the same ones. High use rivers are usually close to towns and cities, easily accessible, and have extensive areas of fishable waters although they may be unattractive and lack solitude. However, there are indications that urban rivers may be valued highly for their scenic beauty while they may receive a low value for recreational fishing.

The Recreational River Survey (Egarr and Egarr 1981) also found that recreational value is not necessarily reflected in user numbers. Ease of access has more effect on user numbers than does the quality of the recreational experience. For passive recreation, scenery involving a river or lake environment is regarded as being of high value, particularly if there are wilderness qualities as opposed to urban or rural surroundings. This is also reflected in the routes taken by tourist buses. For river-based recreation, Egarr and Egarr (1981) found jet boaters value shallow, braided, shingle rivers with access to the river bank and a gentle sloping beach; canoeists value rapids with plenty of water etc.

Factors that determine scenic value were found hard to assess in the survey of recreational rivers (Egarr and Egarr 1981). For example, some people saw gorse as an ugly noxious weed, others see it as colourful ground cover at certain times of year, while still others see it as an attractive addition to barren grassland. Native bush was regarded as having great aesthetic value. Variety of colours and species tended to rank high. While pure sparkling water rated higher than silt laden water, water quality was not of great importance to scenic enjoyment until the pollution became so bad that the smell was oppressive or the sight of rubbish was distracting. Mosley (1989) found that in assessing scenic attractiveness, people appeared to be more strongly influenced by the river environment, such as native forest cover, topographic relief and confinement of the river, than by the characteristics of the river itself.

A pilot study by interview and questionnaire of visitors and residents living adjacent to Hamilton Lake (Happs 1986) showed that perceptions of surface water quality differed widely and were complex, subjective and biased. Interviews and a survey of users of Lake Ellesmere (Ward *et al.* unpublished) revealed the difficulty that people have in evaluating aspects of the environment. Public perceptions of this visually degraded lakewater with regard to water colour and clarity were in general agreement with field measurements. However, different user groups perceived the quality of the water differently (Makowski and Ward 1988).

A survey of the recreational use of beaches in the Wellington Harbour Maritime Planning Area (Doucas and Chin 1987) suggested that people valued Wellington beaches for a variety of reasons. Most people used a particular beach mainly because of its convenience or proximity to home, secondly because it was sheltered from the wind and thirdly, it was safe for swimming. Sandy and non-sandy beaches showed no difference in the most popular activities of swimming and sunbathing. The highly modified beaches showed no difference in use from the 'natural' beaches. Similarly, in a study undertaken to investigate public preferences for New Zealand river scenery (Mosley 1989), several rivers in strongly modified landscapes were more highly regarded than some rivers in wilderness settings.

As part of a study of the natural resources of Wellington Harbour, preference surveys were used to identify visual values of the area (Evans and Meade-Rose 1988). Three groups were surveyed: Wellington residents, travellers and commuters, and users of the harbour area. The response to a series of photographs of the Harbour showed that the most preferred photograph was one of the inner harbour, except to the user group surveyed, while the least preferred by all groups was the Hutt River estuary. Of the landscape units presented, people preferred natural/unspoilt areas without buildings. Buildings and structures that are integrated with the landscape were definitely preferred to a cluttered arrangement of buildings and structures, particularly when they are near the shore. People value access to the sea and grassed recreation areas adjacent to beaches.

The value that people place on aspects of the environment, therefore, depends upon their cultural, social and educational background and on whether, or how, they intend to use the particular environmental component. A valued environmental component may be regarded as a type of environmental indicator in that it identifies an aspect of the environment that is perceived as having value.

10.1 Management implications of valued environmental components

Vecs must first be identified using methods such as those suggested above and then incorporated into the management of the resource. The examples that have been given of values towards aquatic landscapes imply that management of modified landscape features that are highly valued, such as beaches or rivers in urban situations, may be just as important as maintaining wilderness features. It is also apparent that the landscape surrounding the beach, river or lake may be as highly valued as the water body itself and requires careful management.

As we have seen, people's attitudes vary considerably and change over time just as the state of the environment changes. Consequently the components that are valued will also vary. So while it is important to identify them and take account of them in management there must be allowances for amendment with time i.e. provision for review of management objectives.

Management of resources needs to take into account any effect of natural events or human activities on the valued aspects of the environment. The effects of stress on the environment itself, as discussed in this report, may be identified by environmental monitoring and the use of indicators. While monitoring changes in the values that people place on aspects of the environment is difficult, if not impossible, the initial identification of the vecs and then periodic feedback through public participation should allow the resource to be managed for its values to people. Appropriate indicators of the condition of the vecs can be used to assess any change.

It is important to create and maintain communication between management and "communities of interest". Interest groups and individuals must have access to management agencies through direct communication, suggestion boxes etc. Field officers must also communicate with users of resources to gauge their satisfaction with the quality of the environment or their abhorrence of unacceptable conditions. This two-way communication is easier at the regional and local level than at the national level. People tend to voice their opinions more vigorously when an unacceptable situation occurs in their neighbourhood. Attitudes towards the state of national resources, such as parks or endangered native plants and animals, may need to be gauged indirectly through written communication with interested parties. However, there must always be an open channel for verbal communication for those who prefer.

The Department of Conservation (DOC) recognises the need for wider representation in public participation. A survey of individuals and organisations who made submissions

on the management plan of the Tararua Forest Park and/or the Tongariro National Park was carried out by DOC. Typically submissions were made by “high income, tertiary educated, high status occupational groups. The majority who made submissions were male, and Maori representation was almost invisible” (James 1990). There is an urgent need to investigate how a much wider range of views and interests can be incorporated into management planning and DOC suggests developing a variety of participation opportunities including involvement in plan formulation (James 1990). It is important to communicate with the appropriate level in Maoridom and the iwi authorities may not always be the appropriate level. Much information is held at the *whanau* or extended family level (M. Love, Ministry for the Environment, pers. comm.) and it may not be readily passed on or shared for one reason or another. Frequent consultation between management agencies and the tribal elders is required so that the latter can become involved in decision-making.

11. Conclusions

A State of the Environment reporting system for New Zealand requires a commitment to long-term environmental monitoring. A survey of environmental monitoring agencies in this country has shown a marked shift towards short-term, client-based projects at the expense of long-term monitoring programmes. Institutional changes resulting from government restructuring have resulted in the tendency for long-term data to be collected only as spinoffs from short-term projects. It is important that agencies undertaking short-term contract monitoring should keep a longer term goal in view and maintain long-term monitoring wherever possible. Long-term records could be invaluable under conditions of climate change or the introduction of an unwanted species. The establishment of Long-Term Ecological Research (LTER) sites in this country would help to maintain long-term monitoring and create links with the international monitoring network.

The survey indicated that little monitoring is undertaken to assess the impact of human activities on the environment. A framework, such as one focused on environmental stress and response, is needed to organise the information collected through monitoring to reveal any gaps and overlaps and to develop indicators of environmental response to human activities. With the restructuring of government agencies, an increased responsibility for monitoring has been placed on local and regional authorities. It is important that this monitoring is carried out consistently between agencies and regions so that the results can be used to contribute to a national picture of the state of the environment.

To develop meaningful environmental indicators for an SER there is a need for clear precise objectives from management agencies so that the indicators can be used to reflect whether the objectives are being achieved. There is also a need to identify environmental components that people value and to incorporate these values into management. On-going communication between management agencies and tangata whenua, interest groups and individuals must take place so that their perceptions and values can be incorporated into management planning. Since neither the environment nor the views of people are static, periodic reviews of indicators and management objectives by scientists and management agencies are essential.

The corporate plans or statements of intent of management agencies would be the appropriate place to set out these management objectives and the indicators that are proposed. It may be possible to use indicators of the state of the environment to provide an assessment of the effectiveness of current policy if they are combined graphically with

policy indicators. In addition, a list of measures of performance in the corporate plan would provide an opportunity for the effectiveness of policies and the achievement of objectives to be assessed.

12. Recommendations

1. A State of the Environment reporting system needs to be based on long-term monitoring and links with the potential LTER network must be encouraged. Central government funding is needed to provide assistance for the continuation of long-term environmental monitoring programmes.
2. A framework to organise the information for a State of the Environment reporting system needs to be selected by the Ministry for the Environment. From the literature surveyed a framework based on the Canadian stress-response model would be appropriate.
3. Indicators that reflect the state of the environment must be based on the objectives of the agencies that are responsible for managing the environment. Examples of indicators provided in this publication need to be circulated to monitoring and management agencies to be modified, augmented and related to management objectives for subsequent use.
4. Communication between monitoring and management agencies and the Ministry for the Environment should ensure that all appropriate indicators have been identified and that agencies with similar objectives are monitoring the appropriate indicators to prevent gaps or duplication of effort.
5. On-going communication between management agencies and tangata whenua, interest groups and individuals must be facilitated so that people's perceptions and values towards the environment can be identified and incorporated into management.
6. Management objectives and the proposed indicators of the state of the environment need to be set out in management agency corporate plans or statements of intent. This will allow a clear overview of the scope of environmental monitoring covered under agency objectives.
7. The use of indicators should be extended to provide an assessment of the effectiveness of policy. This could be obtained either by graphically combining environmental indicators with policy indicators or by the use of performance indicators applied to management objectives and listed in agency corporate plans.

13. References

- Bernard, D. 1987. Community or ecosystem level indicators. *In: Ecological indicators of the state of the environment: Report of a workshop held May 27-29, 1987 at Institute for Environment Studies at the University of Toronto, Canada.* pp.15-18.
- Bird, P.M. and Rapport, D.J. 1986. *State of the Environment Report for Canada.* Canada Ministry of Supply and Services, Ottawa.
- Bressers, H.Th.A. 1988. Effluent charges can work: the case of the Dutch Water Quality Policy. *In: Environmental policy in a market economy.* F.D. Dietz and W.J.M. Heijman (Eds). Pudoc, Wageningen. pp. 5-39.
- Clark, W.C. 1986. Sustainable development of the biosphere: themes for a research program. *In: Sustainable development of the biosphere.* W.C.Clark and R.E.Munn (Eds). IIASA. pp.5-48.
- Crutzen, P.J. and Graedel, T.E. 1986. The role of atmospheric chemistry in environment development interactions. *In Sustainable development of the biosphere.* W.C. Clark and R.E. Munn (Eds.). IIASA. pp.213-251.
- Department of Arts, Heritage and Environment, 1985. *State of the Environment in Australia.* Australian Government Publishing Service, Canberra.
- Dickenson, B. 1988. Environmental indicators for development planning: a gleam in anyone's eye? Workshop on social indicators, 23-25 August, 1988.
- Doucas, D. and Chin, E. 1987. Recreational use of beaches: an assessment of passive opportunities within the Wellington Harbour Maritime Planning Area. Report to Wellington Maritime Planning Authority.
- Egarr, G.D. and Egarr, J.H. 1981. New Zealand recreational river survey, Part 1, Methods and conclusions. *Water and Soil Miscellaneous Publication 13.*
- Elkin, T.J. 1987. State of the Environment Report Regional Municipality of Waterloo. Working Paper series no. 23. School of Urban and Regional Planning, University of Waterloo, Waterloo, Ontario.
- Evans, B. and Meade-Rose, J. 1988. Wellington Harbour natural resources study: visual values. *In Proceedings of a Workshop, 8-9 February 1988, Wellington.* Wellington Harbour Maritime Planning Authority. pp. 4-16.
- Friend, A. 1989. Concepts and methods of environmental statistics: Statistics of the natural environment - a technical report. Department of International and Economic Affairs. Studies in Methods Series F. United Nations, New York. 171p.
- Friend, A.T. and Rapport, D.J. 1989. The evolution of information systems for sustainable development. Institute for Research on Environment and Economy, University of Ottawa.

- Gelinas, R. and Slaats, J. 1989. Selecting indicators for State of the Environment Reporting (Draft). Strategies and Scientific Methods, SOE Reporting Branch, Environment Canada, Technical Report Series, Report No.8.
- Graham, B.W. 1984. Lead pollution in Auckland, New Zealand: airborne particulate matter. *New Zealand Journal of Science* 27: 327-336.
- Goldberg, E. 1990. State of the environment reporting in New Zealand. A proposal for a multi-agency project. Ministry for the Environment internal discussion document.
- Happs, J.C. 1986. Constructing an understanding of water quality: public perception and attitudes concerning three different water bodies. Paper presented at the Australian Science Education Research Association 17th annual conference, Adelaide, May 1986.
- James, B. 1990. Public participation in management planning. Science Fact Fiction No.14. Department of Conservation, Wellington.
- Liverman, D.M., Hanson, M.E., Brown, B.J., Meridith, R.W.Jr. 1988. Global sustainability: towards measurement. *Environmental Management* 12(2): 133-143.
- Livesey, C. 1988. Special values and resources. Resource Management Law Reform Working Paper No.1. Ministry for the Environment, Wellington. p.116-153.
- MacRae, D. 1988. State of the environment reporting: the Australian experience. Synopsis of paper presented at first conference of Environment Institute of Australia.
- McRae, S., Taylor, N., Ward, J., Williams, T., Woods, K. 1989. Environmental monitoring. Unpublished report for the Ministry for the Environment. Centre for Resource Management, Lincoln College, Canterbury.
- Makowski, E.H. and Ward, J.C. 1988. Perception, use and water quality of water resources in New Zealand. Proceedings of Second Symposium on Social Science in Resource Management, 6-9 June, 1988 University of Illinois at Urbana-Champaign. pp. 42-43.
- Marsden, M. 1988. The natural world and natural resources: Maori value systems and perspectives. Resource Management Law Reform Working Paper No. 29, Part A. Ministry for the Environment, Wellington. p.2-30.
- Ministry for the Environment, 1990. Environmental research agenda. Ministry for the Environment, Wellington.
- Mosley, M.P. 1989. Perceptions of New Zealand river scenery. *New Zealand Geographer* 45(1): 2-13.
- Organisation of Economic Cooperation and Development, 1985. *State of the Environment 1985*. OECD, Paris.

- Rappart, D. 1987. Criteria for ecological indicators. *In: Ecological indicators of the state of the environment: report of a workshop May 27-29, 1987 for Environment Canada.* P. Stokes and D. Piekarz (Eds). University of Toronto Institute for Environmental Studies, Canada. pp. 5-9.
- Rappart, D. and Friend, A. 1979. Towards a comprehensive framework for environmental statistics: a stress-response approach. Catalogue 11-510. Statistics Canada, Ottawa.
- Sevicke-Jones, G.T. 1989. Eutrophication of the Waihi-Temuka River system. South Canterbury Catchment Board Publication, April 1989.
- Sheehy, G. 1989. Organisational and spatial frameworks for State of the Environment reporting. Strategies and Scientific Methods, SOE Reporting Branch, Environment Canada, April, 1989.
- Smith, D.G. 1986. Water quality indexes for use in New Zealand. Part 1 Development strategy and selection of determinands. Water Quality Centre, Ministry of Works and Development, Hamilton. Internal report No. IR/87/03.
- Smith, D.G. 1989. A new form of water quality index for rivers. *Wat. Sci. Tech.* 21(2):123-127.
- Smith, D.G., McBride, G.B., Bryers, G.G., Davies-Colley, R.J., Quinn, J.M. and Vant, W.N. 1989. A National Water Quality Network for New Zealand. D.S.I.R. Water Quality Centre Consultancy Report 8016/2.
- Statistics Canada, 1986. *Human activity and the environment: a statistical compendium.* Ministry of Supply and Services, Ottawa, Canada.
- Steven, J. 1990. Environmental quality monitoring - analysis of a survey of public agencies. Unpublished report for the Ministry for the Environment. Centre for Resource Management, Lincoln University, Canterbury.
- Stokes, P. and Piekarz, D. (Eds.). 1987. Ecological indicators of the state of the environment: report of a workshop May 27-29, 1987 for Environment Canada. University of Toronto Institute for Environmental Studies, Canada. 152 p.
- Tierney, L. 1987. Angler perceptions. *New Zealand Limnological Society Newsletter, No. 23:* 17.
- Tierney, L.D. 1988. The New Zealand river angling survey (Abstract only). *Verh. Internat. Verein. Limnol.* 23: 1805-1806.
- Vant, W.N. 1987. What are we getting into? Recreation and water appearance. *Soil and Water* 23(4): 2-6.
- Vos, J.B., Feenstra, J.F., de Boer, J., Braat, L.C., van Baalen, J. 1985. Indicators for the state of the environment. Institute for Environmental Studies, Free University, Amsterdam.
- Ward, J and Talbot, J. 1988. Water quality management. Information Paper No.8, Centre for Resource Management, Lincoln College, Canterbury.

Appendix 1: Environmental monitoring questionnaire

B. State of the Environment Reporting

The Ministry for the Environment is preparing a proposal for a multi-agency State of the Environment Reporting system for New Zealand. This definition is offered by the Ministry: "State of the Environment Reporting (SER) can be regarded as the last step of an environmental quality monitoring system. It is a system of reporting information provided by environmental quality monitoring for the purpose of good decision-making in environmental management." It also reflects past decision-making.

State of the Environment Reporting (SER) needs to be more than a compendium of statistics. It must be an interpretation of data to indicate the quality of the environment. To achieve this, measurable indicators of environmental quality need to be identified.

As a basis for our thinking I have enclosed a framework of environmental stress and response (p.5, columns 1-6) based on the work of Rapport and Friend (1979) for Statistics Canada. This work was modified and incorporated into a statistical compendium "Human Activity and the Environment" to the State of the Environment Report for Canada, 1986. The framework is not meant to be comprehensive and is a suggested guide only but provides a basis for the selection of indicators of environmental response to stress. A review of overseas literature suggests that those indicators need to be based on the management objectives of your agency. Consequently I have added to the framework (columns 7 and 8) examples of environmental quality objectives and indicators that might be used in SER.

Please consider the activities creating stress from the framework and list the management **objectives** that are relevant to your organisation and suggest **indicators** that might be appropriate.

For example, if your organisation is concerned with forestry, management for sustainable yield and erosion control may be two objectives. Indicators that tell us whether these objectives are achieved or not could be:

- area planted in natives and exotics,
- timber production,
- standing crop,
- area clearfelled: area replanted,
- soil and sediment loss.

Criteria suggested in an Australian report for the selection of environmental indicators are attached as a guide for your thinking.

GUIDE FOR THE SELECTION OF ENVIRONMENTAL INDICATORS

Source: Acil Pty. Ltd Report. Development of Indicators of Environmental Quality

Environmental indicators should:

- be applicable to the whole of a defined segment of the environment, that is, an indicator of forest quality should be conceptually applicable to all Australian forests;
- be based on critical attributes of the ecosystem data collection, storage, retrieval and interpretation programmes;
- where practicable, be based on existing data collection, storage, retrieval and interpretation programs;
- relate directly to the stated environmental quality objectives and to the ecosystem being measured. In ensuring this the following factors should be considered:
 - what parameters adequately describe the ecosystem under consideration,
 - what parameters best demonstrate change in the condition of that ecosystem,
 - how many lines of evidence are needed to validate the conclusions reached.
- enable spatial and temporal trends in environmental quality to be assessed;
- optimise information and cost-effectiveness in the measure of the environmental quality objective;
- facilitate broad community environmental quality assessment and awareness; and
- be measurable by relatively unsophisticated, inexpensive, quick, accurate and readily available methods and equipment.

The relationship between environmental quality and the indicator must be known, and preferably linear, over the full range of the measurement.

stress	creating stress	activity	stress on environment	response	response	quality objectives	environmental response
Natural	Climate regime	Floods, storms, earthquakes	Erosion rates Landscape change	Changes in air, water, soil character Changes in biotic state	Modification of the environment		
Population (human)	Population dynamics	Population growth, migration	Change in demand on natural resources Changes in birth, death, sickness rates	Change in biotic state	Land use zoning	Control of urban sprawl	
Harvesting	Agriculture Horticulture Forestry Fisheries	Production	Changes in soil character Stock depletion Changes in age structure	Changes in biotic state (pop. size, regen. capacity)	Conservation Changes in methods of farming, harvesting, fishing Legislation TAC	Manage for sustainable use Control pollution incl. water quality Control erosion Control nuisance sp. and disease organisms	Area in type of use No. reported cases of pollution in soil, surface & groundwater Area cleared/ploughed: replanted Soil and sediment loss Area occupied by nuisance species Incidence of disease
Extraction & depletion of non-renewable resources	Mining Fossil fuels	Extraction	Depletion of resources Landscape change	Substitution for scarce resources leads to impacts indirectly from wastes and restructuring assoc. with use of substitutes	Restrictions on non-renewables and substitution		
Environmental modification	Land conversion Transport networks	Construction Exploration Recreation	Land converted, changed in character	Changes in air, water, soil character Changes in biotic state due to habitat change	Changes in rate and location of land conversion Land use legislation Park, reserve creation	Maintain reserves repres. of ecosystems, ecological communities and habitats Manage areas for recreational use	Proportion natural areas set aside as parks, reserves Species diversity Standing crop No. rare & endangered sp.
Waste generation	Mining Manufacturing Energy generation Transportation Households	Production Consumption Vehicle movements	Waste generated Emissions to air, water, soil Disposal of toxics Noise generation	Changes in air, water, soil character Changes in biotic state Human health effects	Pollution control through process change Legislation Conservation	Maintain environ. health and aesthetics	No. reported cases of air, soil, water pollution No. days/yr levels CO, smoke, lead rise above international safety standards Species diversity Incidence of contaminant poisoning

Appendix 2 Agencies that responded to Part B of questionnaire

Catchment Authorities and Regional Water Boards: Auckland
Marlborough
Otago

Department of Conservation, Science and Research Directorate, Wellington (2 replies)

Department of Health Health Protection Programme, Wellington
National Radiation Laboratory, Christchurch

DSIR Division of Water Sciences, Water Resources Survey, Wellington
Division of Water Sciences, Water Quality Centre, Hamilton
NECAL Laboratory, Auckland
New Zealand Geological Survey, Lower Hutt

Department of Statistics, Auckland

Land Corporation, Science Advisory Group, Christchurch

MAF MAFTech, Ruakura Agricultural Centre, Aquatic Plant Section, Hamilton
MAFTech, Invermay Agricultural Centre, Mosgiel
MAFFish, Fisheries Research Centre, Rotorua

Ministry of Forestry Forest Research Institute, Rotorua

New Zealand Forestry Corporation, Wellington