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Environmental performance indicators

Technical Paper No. 48 Biodiversity

Environmental Performance Indicators: An analysis of potential indicators for freshwater biodiversity.

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Signposts for sustainability

Title: An Analysis of Potential Indicators for Freshwater Biodiversity

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Executive Summary

Freshwater biodiversity

Biological diversity is the variety of life: plants, animals and microorganisms, the genes they contain and the ecosystems they form. It includes:

- Genetic diversity
- Species diversity
- Ecosystems diversity
- Functional diversity

In this report, freshwater ecosystems include river and stream systems, lakes, freshwater wetlands, geothermal ecosystems and underground aquifers.

The issues analysis process identified a number of issues relating to freshwater biodiversity and freshwater fisheries. Key issues include:

- Most lowland river systems have been ecologically degraded by biological invasions, sediment/contaminant fluxes, channelization or the removal of floodplain connections.
- Many lakes (especially those in lowland and coastal areas) have been degraded by eutrophication. Most lake fish communities are dominated by introduced species, and invasive exotic plant species are extensive in most lake systems.
- Less than 10% of the original mosaic of wetland systems remain today. Many of the remaining wetlands have been degraded to varying degrees by invasions of alien plants, fish and waterfowl, modifications to hydrological regimes or barriers to fish migration. The loss of wetland extent and diversity is continuing.
- Alien biota threaten some indigenous freshwater taxa. They have damaged and continue to damage entire indigenous community structures and functioning.

The extent of alien plant invasion in freshwater ecosystems (especially rivers and lakes) has been invisible to most people and few resources have been allocated to eradication or control.

This report

The purpose of this report is to review potential freshwater indicators developed through a series of workshops held by the Ministry for the Environment between April and September 1998. This review was required to address the following for each of the potential indicators:

- an explanation of the indicator
- identification of the relevant freshwater biodiversity issues (used in the indicator development process)
- relevant national policy goals
- current research, monitoring and databases
- possible methodology and reporting
- an analysis of the usefulness and practicality of the potential indicator (commentary)

Indicators have been confirmed for the freshwater strand of the EPIP. Some of those indicators are relevant to freshwater biodiversity and are discussed in this report.

The potential indicators

This table summarizes the main recommendations/suggestions for each of the reviewed indicators.

Potential indicator	**Summary**
FW 1. The extent and condition of wetlands	This is a confirmed stage 2 indicator in the freshwater strand of the EPIP. This could be expanded to include changes in the condition of rivers and lakes.
FW 2.% occurrence of the native fish species giant kokopu and red finned bully with increasing elevation and distance inland.	This is a confirmed stage 2 indicator in the freshwater strand of the EPIP. It is intended to provide a measure of the quality of some freshwater ecosystems. It is difficult to assess how useful this indicator will be from a biodiversity perspective. There are questions about the appropriateness of using giant kokopu given its narrow range of preferred habitats and the lack of East Coast records. The indicator may identify whether there have been any changes to the habitat characteristics that affect the abundance and/or distribution of giant kokopu and red finned bully. It is unclear whether changes in the abundance and distribution of these two species would represent changes for other freshwater fish species.
FW 3. Macroinvertebrates in rivers.	This is a confirmed stage 2 indicator for the freshwater strand of the EPIP. While traditionally macroinvertebrate data has been used to assess water quality (primarily using the Macroinvertebrate Community Index and its variants) it appears that this indicator may have a broader focus. If appropriate macroinvertebrate data collection and management protocols are established it should be possible to use macroinvertebrate data to provide useful information about the biological condition of rivers and streams.
FW 4. % endemic taxa in different habitat types.	It is suggested that this indicator not be further developed because it would require considerable effort to monitor changes and the results would be ambiguous. Any observed changes may well reflect changes in knowledge (e.g. more endemic species identified) and the numbers of alien species.
FW 5. The relative abundance or presence/absence and distribution of selected indicator species compared to historic and current baselines.	Changes to indicator species should represent changes in other species. As there is little known about many species it is difficult to know whether observed changes in the distribution and abundance of particular species reflects similar changes in other species. Blue duck and grebes could be used as indicator species subject to further discussion about their representativeness. Koura (freshwater crayfish) could be considered in future when the outcomes of current research are known. It appears that there are no suitable indigenous plant indicator species.
FW 6. The number and % of threatened species in different IUCN threat categories.	The IUCN criteria do not adequately address New Zealand's special characteristics but should be included because they provide internationally comparable data. It is recommended that this indicator be amended as follows*: the number of taxa in different IUCN and New Zealand threat categories.* Specific New Zealand criteria that

	address the special features of New Zealand's marine and freshwater environments are needed.
FW 7. The condition and abundance of trout.	This indicator tells more about the effectiveness of the management of trout habitat (e.g. water quality) and population stocks, than about biodiversity. If this potential indicators is retained, it would be more appropriately located in the water strand of the EPIP.
FW 8. Presence and extent of alien plant cover by waterbody ecotype.	It is suggested that this potential indicator be re-framed as follows*:* *The distribution of troublesome (plant) alien species.* *The relative extent of indigenous and alien dominated plant communities in lakes.* *The extent of characean communities (*this is also a condition indicator).
FW 9. The number and types of alien fauna species present by waterbody ecotype.	It is suggested that this component be combined with part of potential indicator FW8 in a revised indicator: *The distribution of troublesome alien species*.
FW 10. The number of ecotypes/waterbodies free from alien species	It is suggested that this indicator be re-framed as: T*he number of waterbodies free from invasive plant, mollusc and vertebrate species*.
FW 11. The length of rivers that are modified by type of modification.	If just structural modifications (e.g. channelization, barriers to fish passage) are addressed this would be relatively simple to implement. It may be appropriate to consider modifications resulting from abstractions and changes in sediment and nutrients. This potential indicator could be incorporated within a general river condition indicator if that option is pursued.
FW 12. % rivers affected by artificial barriers to fish passage.	This is incorporated within potential indicator 11.
FW 13. % water ecotypes remaining today that are legally protected, by type of protection.	This is a useful policy relevant indicator. As different types of legal protection have different outcomes (e.g. a water conservation order v. a protected area statute) it would be appropriate to identify the extent of each type of protection.
FW 14. % freshwater margin with legal and unobstructed public access.	This is a policy relevant indicator but it is not specifically related to biodiversity. It would most appropriately be addressed in the water strand and/or combined with the equivalent potential indicator from the marine environment strand.

Purpose of This Report

This is one of several reports reviewing potential biodiversity indicators for the Environmental Performance Indicators Programme. Other reports address marine biodiversity (Froude, 1998b) and terrestrial biodiversity (Froude, 1998c).

The purpose of the EPI Programme is to develop a set of national environmental indicators for State of the Environment Reporting. The Ministry for the Environment is coordinating the development of this programme under an April 1993 cabinet directive.

The purpose of this report is to review potential indicators for freshwater biodiversity proposed by working groups that met during 1998. This review was required to address the following for each of the potential indicators:

- An explanation of the indicator
- Identification of the relevant marine biodiversity issues used in the indicator development process
- Relevant national policy goals
- Current research, monitoring and databases
- Possible methodology
- An analysis of the usefulness and practicality of the potential indicator (commentary)

Details of the indicator development process that led to these potential indicators are in the EPI Programme terrestrial and freshwater biodiversity discussion document (Ministry for the Environment, 1998). Recent negotiations between the Ministry for the Environment and the Department of Conservation led to the incorporation of a modified set of proposed freshwater indicators in that document.

Biological Diversity Introduction

Defining Biological Diversity

The Convention on Biological Diversity defines biological diversity as: " the variability among living organisms from all sources including inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are a part. This includes diversity within species, between species and of ecosystems."

Biological diversity is, therefore, the variety of all life on earth: plants, animals and microorganisms, the genes they contain and the ecosystems they form. It includes:
- genetic diversity
- species diversity
- ecosystems diversity
- functional diversity

Genetic diversity

Each species consists of one or more populations of individuals. Because different populations have limited genetic mixing, they tend to diverge genetically because of mutation, natural selection and genetic drift. Natural selection and genetic drift are the main forces leading to genetic diversity within species (Smith, 1994).

Under natural selection the most fit individuals leave more offspring than less fit individuals. Genetic drift results in chance fluctuations in allele frequencies between generations. In small populations these random changes may result in a loss of alleles. This will decrease the genetic diversity in these populations.

In general a loss of genetic diversity occurs through genetic drift (migration can counteract this) and through the selective removal of specific genotypes. Any activities or processes that selectively harvest individual types or severely decrease population size, will change the genetic structure of small populations (Smith, 1994). Froude (1998d) discusses changes in genetic diversity resulting from the selective harvest of certain size classes of fish by fisheries activities.

Species diversity

This is the most obvious level of biological diversity. When species richness is viewed as the sole component of biodiversity, as is often is (Norse, 1994) this can mean that maximum species richness becomes a target or a value in itself. High species richness at a site may not relate directly to a site’s relative value for biodiversity conservation, as a site with maximum species richness may reflect an intermediate level of disturbance and reasonably resilient species.

Ecosystem diversity

Ecosystems differ not only in the species composition of the communities, but also in their physical structures and what the species in their communities do (function). For example, the composition, structure and functioning of the biological communities found in lowland eutrophic lakes and fast flowing mountain streams are very different. The pathways of energy flow and the proportions of organisms performing particular functions also differ markedly between ecosystems. Individual ecosystem types, for example wetlands, also differ due to different physical conditions such as varying nutrient inputs.

Diversity of function

In all but the least diverse ecosystems species can be categorized into functional groups or guilds based on similarities in what they do. For example, species of polychaete worms in an area of seabed can be aggregated into guilds based on their methods of feeding (e.g. eat other worms, filter bacteria from currents); where they live (e.g. construct permanent burrows, hide under hard objects, construct tubes that project above the sediment surface); and reproduction (e.g. whether they mature quickly or slowly, produce many eggs). Biochemical diversity (e.g. organisms in geothermal pools) is another form of functional diversity.

New Zealand's Freshwater Biodiversity

New Zealand has more than 70 major river systems, thousands of streams, more than 770 lakes and numerous underground aquifers containing cool ground water or hot geothermal fluid (Taylor & Smith, 1997).

Most lowland freshwater river systems have been ecologically degraded through one or more of:
- a high level of biological invasions
- increased levels of sediment, nutrients and contaminants
- channelization, stop banking and removal of meanders
- removal of floodplain connections
- construction of dams and other barriers to native fish migration
- removal of indigenous riparian vegetation.

Most lowland lakes have been ecologically degraded by eutrophication, drainage (especially of adjoining wetlands) and biological invasions. Today very few lowland freshwater systems are close to their natural state because of the pervasive effects of alien plants and animals including trout.

Various attempts have been made to estimate the extent of wetlands remaining. The 1997 State of Environment Report (Taylor & Smith, 1997) reported a Landcare Research estimate that the original area of freshwater wetlands was 672 000 hectares while the current extent is 100,000 hectares. This represents an 85% decline since European settlement. This excludes the 45,000 hectares of pakahi heathland in the Western South Island and Stewart Island that does not appear to have changed since pre-European times.

There is considerable regional variation in the extent of loss. For example, unmodified wetlands have been reduced to approximately 37% of their original extent in Southland, 15% in the Waikato and less than 1% in the Bay of Plenty (Cromarty & Scott, 1996).

Different types of wetlands have shown different rates of loss. For example ephemeral wetland systems such as those in dunelands, have been impacted more than lacustrine (standing open water) wetlands. Many of the remaining wetlands have been degraded to varying degrees by invasions of alien plants, fish and waterfowl; modifications to the hydrological regimes of the wetland itself and/or the surrounding lands; and barriers to fish passage.

McDowall (1997) describes how the New Zealand fish fauna has increased from 27 species recognized in 1990 to at least 35 species now—a growth of nearly 30%. This increase is made up of; two species that were formerly rejected; four new species; and one Australian species (spotted eel) which arrived in New Zealand waters by natural dispersion processes and has since become established here. The total number of native fish species is low compared to other countries, although nearly 90 percent are endemic. Many indigenous freshwater fish species have a marine stage in their life cycles. This is unusual and may result from New Zealand's long period of inundation during the Oligocene drowning (Taylor & Smith, 1997).

Today one indigenous freshwater fish species is extinct (grayling), approximately one-third are threatened and several others are rare. The New Zealand Freshwater Fish Database, which is maintained by the National Institute of Water and Atmospheric Research (NIWA), has approximately 13,000 records (Richardson, 1993). Long finned eels are the most commonly reported species (at 48% of sites) with the migratory galaxids being much less abundant. The main threats to native fish include:

- introduced species (especially brown and rainbow trout) which act as predators and competitors;
- habitat destruction/modifications resulting from human activities. Damaging human activities include: forest and riparian margin clearance, pastoral farming, the construction of dams and other barriers to fish passage, the channelization of rivers and the drainage of wetlands and lakes.

At least 90% of freshwater invertebrates are likely to be endemic and have a restricted distribution (Taylor & Smith, 1997). To date there are approximately 450 formally identified insect species and at least 200 other kinds of invertebrates (Collier, 1993).

Trout can also adversely affect invertebrate species. Crayfish have been reduced to such extent by trout predation that it is hard to find crayfish in areas where are trout present (McDowall, 1968). Trout may also compete with blue ducks for food (Towers, 1996).

New Zealand freshwater habitat conservation

Although a significant proportion of upland streambeds are included within formally protected areas (e.g. reserves, national parks), very few lowland river systems have any legal protection. While there are a number of lakebeds that are formally protected (at least in part) this has little effect unless the catchment is appropriately managed to protect the lake habitats. As with rivers the majority of protected lakebeds are in upland areas.

Parts of six river systems and two lakes have been protected by water conservation orders issued under the Resource Management Act 1991, or its predecessor the Water and Soil Conservation Act 1967. Water conservation orders protect the river or lake itself—they do not apply to the catchment or riparian margins.

While a number of the few remaining wetlands are legally protected many wetland areas on private land remain unprotected.

The concept of freshwater habitat protection is more complex than it is for terrestrial habitats. Legal protection is one aspect of protection and needs to apply to both the bed and the water. As with terrestrial ecosystems appropriate management of the freshwater system is required. Whereas in terrestrial habitats this can largely be confined to the terrestrial habitat concerned and a buffer, appropriate management of the entire catchment and especially the riparian margins is needed for freshwater habitats.

In the case of geothermal ecosystems the geothermal aquifer needs to be protected from fluid and energy extraction. While a number of geothermal ecosystems are legally protected by being included in reserves, they are in reality unprotected because their geothermal aquifer is open to fluid or energy exploitation.

Review of potential freshwater biodiversity indicators

Introduction

This report reviews a series of potential freshwater biodiversity indicators which were developed through a series of workshops run by the Ministry for the Environment between April and September 1998. These workshops included representatives of the scientific community, relevant government agencies, regional councils and community/sector groups. The indicators are:

FW 1. The extent and condition of wetlands
FW 2. The percentage occurrence of the native fish species giant kokopu and red finned bully with increasing elevation and distance inland
FW 3. Macroinvertebrates in rivers
FW 4. The percentage of endemic taxa in different habitat types
FW 5. The relative abundance or presence/absence and distribution of selected indicator species compared to historic and current baselines
FW 6. The number/percentage of threatened species in different IUCN threat categories
FW 7. The condition and abundance of trout
FW 8. Presence and extent of alien plant cover by waterbody eco-type
FW 9. The number and types of alien fauna species present by waterbody eco-type
FW 10. Number of eco-types/waterbodies free from alien species
FW 11. The length, or percent of length, of rivers that are modified by type of modification, by order, by eco-type
FW 12. The number/percentage of rivers affected by artificial barriers to fish passage
FW 13. The percentage of water eco-types remaining today that are legally protected, by type of protection
FW 14. The percentage freshwater margin with legal and unobstructed public access

The review format for each indicator consists of:
- an explanation about the indicator and what it could show (rationale)
- identification of the relevant freshwater biodiversity issues used in the indicator development process
- relevant national policy goals
- existing monitoring, research and databases
- possible methods for implementing the indicator
- a commentary which analyzes the usefulness and practicality of the indicator
- a list of related indicators

Stage 1 indicators are those that can technically be implemented now, while Stage 2 indicators are those that require further development work. The Ministry for the Environment is using the Pressure-State-Response mode for indicator development. Pressure indicators are those that represent threats to the environment; State indicators represent the environment's condition; while Response indicators represent society's responses to the pressures on, and the state of, the environment.

Scope of the freshwater biodiversity technical paper

This paper addresses freshwater biodiversity. This includes freshwater species and the following ecosystems: rivers and streams, freshwater wetlands, lakes, geothermal systems, karst systems and underground aquifers.

General freshwater indicators such as those relating to water quality are described in Ministry for the Environment (1997, 1998). These general freshwater indicators are further developed than the biodiversity indicators. Some of the general freshwater indicators use biological components to measure environmental health. The general freshwater indicators and the freshwater biodiversity indicators should be seen as being complimentary.

Terrestrial biodiversity is addressed in Froude (1998c) while marine biodiversity is addressed in Froude (1998b).

FW1. The extent and condition of wetlands

Explanation

It is estimated (Taylor & Smith, 1997) that the original area of freshwater wetlands was 672 000 hectares while the current extent is 100,000 hectares. This represents an 85% decline since European settlement. This excludes the 45,000 hectares of pakahi heathland in the Western South Island and Stewart Island that does not appear to have changed since pre-European times. There is considerable regional variation in the extent of loss. For example, unmodified wetlands have been reduced to approximately 37% of their original extent in Southland, 15% in the Waikato and less than 1% in the Bay of Plenty (Cromarty & Scott, 1996). Different types of wetlands have shown different rates of loss. For example ephemeral wetland systems such as those in dunelands, have been impacted more than lacustrine (standing open water) wetlands. Many of the remaining wetlands have been degraded to varying degrees by: invasions of alien plants, fish and waterfowl; modifications to hydrological regimes of the wetland itself and/or the surrounding lands; and barriers to fish passage.

Issues

Less than 10% of the original mosaic of wetland systems remains today. Many of the remaining wetlands have been degraded to varying extents by invasions of alien plants, fish and waterfowl, modifications to hydrological regimes or barriers to fish migration. The loss of wetland extent and diversity is continuing.

Policy goals

- Preserve representative samples of all types of wetlands (Wetland Management Policy, Reserves Act, s3)
- Preserve the natural character of wetlands (RMA,s6a).
- Urgently protect wetlands that meet the IUCN criteria for Wetlands of International Importance (Wetland Management Policy).

- Protect wetlands of national importance, and where appropriate, wetlands of regional and local importance (Wetlands Management Policy)
- Preserve all indigenous freshwater fisheries and freshwater fish habitats (Conservation Act, s6ab).
- Protect, enhance or re-establish wetlands and their access ways which are important for fish (Wetlands Management Policy).

Current monitoring and research

This is a confirmed stage 2 indicator in the freshwater strand of the EPI Programme. A Sustainable Management Fund Programme is developing indicators to measure changes in extent and condition of different wetland types. This programme includes the development of a wetland classification system. Wetlands being addressed by this programme include:
- palustrine wetlands (swamps,bogs,fens,marshes,seeps)
- estuarine wetlands (intertidal and subtidal)
- geothermal wetlands

The programme is being implemented by Lincoln Ventures and involves UNEP Grid, the Department of Conservation, Landcare Research, and a number of regional councils.

There are a variety of local programmes that survey, and in some cases monitor, changes in the extent and condition of wetlands. Some regional councils (e.g. Taranaki) have mapped or are mapping the extent of wetlands in their region. In a number of cases (e.g. Otago) the focus of this effort on “significant wetlands” (as in s6c Resource Management Act 1991). Some territorial local authorities have some form of inventory of the “significant indigenous vegetation and significant habitats of indigenous fauna” (s6c Resource Management Act 1991) within their administrative boundaries. These inventories can include wetlands. The source of information for these inventories is highly variable. Often existing databases (e.g. Sites of Special Wildlife Interest, Sites of Special Biological Interest, Protected Natural Area Programme Surveys, and WERI) are the main sources of information used. It is unlikely that existing territorial local authority inventories would record all the wetlands within a council’s boundaries.

Existing databases that include wetlands are summarised in Froude (1998a). Some of the information in these databases is out of date, especially in locations where there has been considerable land development/land use change over the last 10-20 years. Information provided generally includes the wetland’s location, its size, a general or detailed description and an assessment of the wetland’s ecological values.

Various monitoring programmes address wetland condition and/or species assemblages. Examples include:

a) Wetland birds in the Wellington Conservancy, Department of Conservation.
This programme monitors the absolute numbers of birds for each species at Lake Wairarapa, Lake Onoke, and Lake Papaitonga. Some of these are long term projects. For example, the Lake Wairarapa bird monitoring programme began in the 1960’s.

b) Wetland ecosystem impacts and sustainability, Landcare Research. This programme focuses on the West Coast and Waikato wetlands. It monitors a series of permanent and non- permanent plots that represent the full range of wetland vegetation types in the two regions. The first survey for some sites was in 1924 (after fire) with a subsequent survey in 1994. Parameters measured include: vegetation composition and relative abundance, and peat/substrate microbial characteristics.

c) The response of restiad wetland flora to fire, Department of Conservation. The purpose of this programme is to determine whether fire can be used to enhance indigenous biodiversity in restiad wetlands and whether fire spreads weeds in these wetland systems. It is also designed to identify whether the endangered swamp orchid performs better after fire. The location of monitoring is the Whangamarino Wetland. Parameters being measured include the percentage abundance of all plant taxa, vegetation height, microclimate, and the loss of organic matter and moisture from the plots.

Commentary

This indicator has been confirmed as a stage 2 indicator in the freshwater strand of the EPI Programme. The definition of wetlands being used in this indicator is broad, and includes estuarine as well as freshwater wetlands.

There have been suggestions that this indicator could be extended to include other freshwater systems, especially rivers and lakes. While an indicator measuring the change in extent of rivers and lakes would not be useful, an indicator addressing changes in condition could be valuable. A general condition indicator could replace some of the indicators reviewed in this report.

There is unlikely to be a significant future change in the national extent of rivers (assuming that the extent of rivers is measured as their length rather than the volume of water or the size of their bed). This is because most rivers are now specifically managed to remain in their current channels irrespective of whether these are the “natural” channels. Most of the past reductions in river length have resulted from flood control and drainage schemes that cut off considerable distances of river meanders.

Changes in the national extent of lakes (presumably measured by the area of water) are likely to be ambiguous. The area of many lakes varies considerably due to long-term fluctuations in rainfall. During long-term low rainfall periods, lakes without major inflows can be significantly reduced in area (e.g. Lakes Rotoehu and Rotoma). The construction of new hydro-electric and other storage lakes would further complicate any national figures.

One category of lakes where it could be useful to monitor changes in extent is the dune lakes. The conversion of large areas of indigenous duneland to agriculture and exotic forestry means that very little indigenous duneland vegetation remains and most duneland lakes have been at least partly drained or otherwise modified.

While the indicator as written appears to include geothermal wetlands, it may be worthwhile to specifically identify all geothermal ecosystems as a group. This may result in some overlap with the terrestrial indicators that address ecosystem extent and condition. Geothermal ecosystems include both freshwater and terrestrial components. It would be appropriate to monitor changes in both extent and condition for geothermal communities.

The working group intended that freshwater indicators 8-12 would address changes in condition for freshwater ecosystems other than wetlands. They considered that the condition of wetlands would be addressed by this indicator as it was originally written. If this indicator is extended as discussed then some of the specific condition indicators may become redundant.

FW 2. Percentage occurrence of the native fish species giant kokopu and red finned bully with increasing elevation and distance inland

Explanation

This is a confirmed stage 2 indicator in the freshwater strand of the EPI programme. It is intended that this indicator will provide a measure of the environmental quality for freshwater ecosystems.

About one half of New Zealand's freshwater fish species are diadromous (part of their life cycle requires them to migrate to and from the sea). This feature enables them to become widespread around New Zealand but probably also limits their ability to penetrate and colonise some inland waters. Some diadromous fish species can migrate further inland than other species. This means that there is an upstream decline in species richness and in most cases an upstream decline in density. The processes that cause the variation in species richness and density are rarely the same in different river systems. This makes it difficult to compare species richness and densities between river systems.

McDowall(1996) uses the extensive national freshwater fish database to develop curves of probability of occurrence for each fish species in relation to altitude and distance inland from the sea. He discusses how the probability curves derived from the existing 13 000 sites on the freshwater fish database could be used for comparing equivalent data that would be collected in future. He suggested six species whose probability curves could be compared over time (giant kokopu, banded kokopu, koaro, red finned bully, giant bully, blue-gilled bully). Subsequently, the Ministry for the Environment chose two species (giant kokopu, red finned bully) to use in developing this indicator.

Changes in future probability curves may reflect changes in environmental quality due to one or more of changes in artificial barriers to fish passage (e.g. dams, weirs and flapgates):
- habitat destruction and modification; and
- harvesting.

Issues

- Most lowland freshwater systems are ecologically degraded through biological invasions, sediment and contaminant fluxes , channelization or the removal of floodplain connections.

- Less than 10% of the original mosaic of wetland systems remains today. Many of the remaining wetlands have been degraded to varying extents by invasions of alien plants, fish and waterfowl, modifications to hydrological regimes or barriers to fish migration. The loss of wetland extent and diversity is continuing.
- Freshwater fisheries (e.g. whitebait, eels) have been significantly damaged by habitat loss and degradation.
- Human created migration barriers to freshwater fish (e.g. kokopu and eels) continue to be a problem in many areas.

Policy goals

- Preserve the natural character of wetlands, rivers and lakes and their margins (RMA, s6a).
- Preserve all indigenous freshwater fisheries and freshwater fish habitats (Conservation Act, s6ab)
- Habitat of particular significance for fisheries management should be protected (Fisheries Act, s9).
- Safeguard and restore natural passage for migratory fish (Freshwater Fisheries Regulations).

Commentary

This indicator is intended to provide a measure of the quality of freshwater ecosystems. It is not specifically designed to be a biodiversity indicator even though it uses indigenous species.

McDowall (1996) suggested the use of this type of measure as an alternative to developing an index of biotic integrity. He considered that the absence of knowledge about the quantitative relationships between fish populations and habitat characteristics would compromise any efforts to directly use fish populations as environmental quality indicators. Matters are further complicated by the prevalence of diadromy in New Zealand freshwater fish species. This results in upstream/downstream gradients in species occurrence and abundance. This means that high quality inland habitats are likely to have fewer fish species and/or lower population densities just because of difficulties in access.

The working group discussed the two species that have been chosen for this indicator. The giant kokopu occurs in low altitude streams, has been lost from many areas of New Zealand, may be sensitive to brown trout and is a weak climber (McDowall, 1996). The group questioned the use of this species because it has a narrow range of preferred habitats and there are no records of it throughout much of New Zealand's East Coast. Accordingly, its absence may mean little in terms of environmental quality. The red finned bully is widely distributed in low to mid altitude rocky streams and larger rivers and is a moderate climber (McDowall, 1996).

Information from this indicator may inform about changes in the abundance and distribution of the two species chosen. It is unclear whether changes in the abundance and distribution of these species would be representative of changes in any other species.

This indicator is based on data in the Freshwater Fish Database. While this database has over 13 000 entries the representativeness of this data has been questioned. There is a greater representation of sites that can be sampled by electric fishing machines. This favours sites shallower than 1metre and relatively close to road access. Accordingly, river systems deeper than one metre, lakes, brackish lagoons and ponds are likely to be under represented. Fish species that are not susceptible to electric fishing techniques are also likely to be under represented.

In terms of an indicator of environmental quality this potential indicator may identify whether any changes have occurred to habitat characteristics that affect the abundance and distribution of giant kokopu and red finned bully. It will not identify the nature of or necessarily the extent of the changes.

This indicator is an indirect measure of the extent and condition of some aspects of freshwater ecosystems. Direct measures of freshwater ecosystem condition (e.g. the length of rivers that are modified by type of modification) would be more relevant from a biodiversity perspective. As this indicator has been confirmed (Ministry for the Environment, 1998b) it may be worthwhile to investigate whether the indicator could be adapted to provide more useful information from a biodiversity perspective.

FW 3. Macroinvertebrates in rivers

Explanation

This is a confirmed stage 2 indicator in the freshwater strand of the EPI Programme.

Macroinvertebrates are a diverse array of animals without backbones. In the field they are defined as those animals that are retained by a sieve with a pore size of 0.2-0.5mm. Stream invertebrates include various groups of worms, molluscs, crustaceans, mites and insects. Taxa within these various animal groups have a wide range of habitat requirements, differ in their degrees of tolerance to different chemical factors, and feed in a variety of ways on wide range of food materials.

The central role of macroinvertebrates in the food webs of streams and rivers means that they contain information about the energy base of the ecosystems, water quality, habitat diversity and the availability of food to support fish populations. Quinn and Hickey (1990) sampled macroinvertebrates in 88 rivers throughout New Zealand. They found that mayflies, stoneflies, and predatory caddisflies were associated with cooler, less enriched, steeper and more elevated sites than were snails, crustaceans, chironomids and worms. They also observed the following to be useful indicators of the level of water enrichment:

- the Macroinvertebrate Community Index;
- the presence of certain species;
- the densities of certain widely distributed taxa (e.g. *Deleatidium* species);
- the percentage of predator biomass; and
- the number of ephemeropteran, plecopteran and trichopteran taxa

Issues

Most lowland river systems are ecologically degraded through biological invasions, sediment and contaminant fluxes, channelization or the removal of floodplain connections.

Policy goals

- Protect the natural character of rivers and lakes and their margins (RMA,s6a).
- Preserve all indigenous freshwater fisheries and freshwater fish habitats (Conservation Act, s6ab)

Current monitoring

Boothroyd & Forsch, (1998) identified nine regional councils with macroinvertebrate sampling programmes. As there is no national standard, programmes have been developed independently in different areas. There is no national database of macroinvertebrates distributional information and associated environmental information. The lack of standardization means that comparative studies between regions cannot be made easily.

In New Zealand macroinvertebrate data are commonly analyzed using the macroinvertebrates community index (MCI) and its quantitative(QMCI) and semi quantitative (SQMCI) variants. These indices were originally developed to evaluate organic enrichment of stony streams on the Taranaki ringplain. They rarely perform satisfactorily in soft bottom (especially lowland) streams, fine sediments and silty urban streams.

Another analytical tool for macroinvertebrates is the Index of Biotic Integrity. This compares benthic macroinvertebrate communities relative to a reference site (e.g. Quinn, 1997).

Britain has developed a software package (RIVPACS) that predicts the occurrence probability for particular freshwater taxa and biotic index scores given a particular suite of environmental conditions. This allows comparisons between observed and expected scores. This software is updated at five yearly intervals. Australia has modified the British software to produce AusRivas. This software is regularly updated and operates via the Internet.

Methodology

The methodology for this indicator is being developed. A Ministry for the Environment macroinvertebrate working group meets regularly and has prepared a draft report. It is likely that a suite of measures relating to macroinvertebrates will be developed rather than just using the MCI and its variants. This means that macroinvertebrate data should be able to address more than the water quality focus of the MCI. Consideration is also being given to establishing a national macroinvertebrate database. This will require establishment and maintenance funding and protocols on the use of the data. During early 1999 there will be a trial using the AusRivas computer software.

Commentary

A macroinvertebrates in rivers indicator has been confirmed as part of the freshwater strand of the EPI Programme. While macroinvertebrate data has traditionally been used to assess water quality (by the use of the MCI and its variants) it appears that this indicator may well have a broader focus. In addition it is recognized that the Macroinvertebrate Community Index only works well in certain substrate types. This index rarely performs satisfactorily in soft bottom streams (especially in lowland areas), fine sediments and silty urban streams.

It is likely that the following matters will be considered as part of the development of this indicator:

- Data requirements: this will include identifying what type of associated site data (e.g. catchment land use, stream morphology) should be collected to provide the maximum flexibility in data manipulation.
- What questions should macroinvertebrate data address? Macroinvertebrate data can be used to address biodiversity related matters such as changes in macroinvertebrate species composition and relative abundance.
- Whether there should be a national macroinvertebrate database
- The identification of reference sites for use in an appropriate computer package (e.g. AusRivas).

It is important that the potential uses of macroinvertebrate data be assessed carefully. With relatively little extra effort it should be possible to use macroinvertebrate data to provide useful information about the biological condition of rivers and streams.

FW4. The % of endemic taxa in different habitat types

Explanation

New Zealand has a high level of endemism in its indigenous flora and fauna. Some taxonomic groups have particularly high levels of endemism when compared to the levels in most other countries. Such high levels of endemism are only found in a few isolated islands such as Hawaii. A freshwater example of a group with a high degree of endemism is the freshwater fishes where approximately 90% of the taxa are endemic. Taxa that are endemic to New Zealand are those which are found only in New Zealand.

Issues

- New Zealand biota is both highly distinctive and highly vulnerable to the adverse effects of habitat destruction and alien biota. Today many taxa have a threatened status.
- The reduced range and population sizes of many indigenous species are likely to have reduced the genetic diversity of those species.

Policy goals

- Develop or maintain necessary legislation and/or other regulatory provisions for the protection of threatened species and populations (Convention on Biological Diversity, article 8).
- Ensure the survival of all indigenous species in their natural communities and habitats (Reserves Act, s3).
- Protect wildlife throughout New Zealand (excluding species listed in schedules 1-5 & 8 of the Wildlife Act).
- Preserve all indigenous freshwater fisheries (Conservation Act,s6ab)

Methods

This indicator would require an agreed habitat classification system. A species list would be required for each habitat type. This list would need to identify endemic, indigenous (but not endemic) and alien species. It would need to be updated at regular intervals (e.g. every 5-10 years).

Commentary

It would require considerable effort to compile and review species lists by habitat type rather than the more usual location focus.

A major variable that will affect the percentage of endemic species in a particular habitat will be the number or percentage of alien species in that habitat. A reduction in the percentage of endemic species in a particular habitat could be for any one of the following reasons:

- certain endemic species no longer exist in that habitat
- certain endemic species were not found at the time of the survey in the habitat
- there are more alien species in the habitat

An increase in the percentage of endemic taxa could occur if there was a loss of indigenous but not endemic species. This could appear to be a conservation gain when it would actually be a loss.

The percentage of an endemic species could be significantly reduced by a large number of non-invasive alien species. The presence of only one or two invasive species could have a far more significant effect on the environment , but have a relatively small effect on percentage of endemic species.

It is suggested that this indicator not be further developed. It would be more appropriate to use the percentage of endemic taxa in different habitat types as a descriptor of the environment rather than an indicator of environmental change.

FW 5. The relative abundance or presence/absence and distribution of selected indicator species compared to historic and current baselines.

Explanation

The purpose of this proposed indicator is to use the trends in several indicator species to represent the trends in relative abundance and distribution for a wider range of species and/or particular ecological communities. During the working group sessions a variety of species and parameters were suggested including:

- blue duck (upland river habitats: relative abundance)
- grey duck (lowland wooded wetland habitats: relative abundance)
- grebes including dabchick (lowland lake habitats: relative abundance)
- freshwater crayfish (koura), (river and lake habitats: presence/absence or relative abundance)
- *Deleatidium* mayfly (presence/absence)
- characean meadows (relative extent)
- *Isoetes* (presence/absence)
- *Myriophyllum* species (presence/absence)

The working group sought to include a variety species that collectively represented a range of taxonomic groups; a range of habitat types; and common and threatened species.

Issues

- New Zealand biota is both highly distinctive and highly vulnerable to the adverse effects of habitat destruction and alien biota. Today many taxa have a threatened status.
- The distribution and population sizes of many indigenous species have been reduced. It is likely that this has reduced the genetic diversity of those species.

Policy goals

- Ensure the survival of indigenous species in their natural communities and habitats (Reserves Act, s3).
- Protect wildlife throughout New Zealand (Wildlife Act).
- Promote the maintenance of viable populations of species in their natural surroundings (Convention on Biological Diversity, article 9).

Current monitoring and research

Department of Conservation species programmes

There is a national programme to monitor the population status and trends of blue duck. This programme began in 1986 and there are annual surveys to count the number and status of birds on various rivers. Pairs are monitored to determine the number of fledglings produced. Birds are banded to gain an understanding of mortality rates and bird movements.

The Department has a number of other monitoring and research programmes for indigenous freshwater species including: brown teal, Hochstetters frog (Thursen, 1998) and the black stilt.

Other agencies species monitoring programmes

The Ornithological Society of New Zealand has prepared an Atlas of Bird Distribution in New Zealand. This records the presence/absence of individual bird species within 10000 yard grid squares.

Most regional councils and some research institutes collect macroinvertebrate data that would include information on the *Deleatidium* mayfly.

A University of Otago study on the ecology of freshwater crayfish in the Taieri River System included the compilation of a database on the present and past freshwater crayfish distribution. This database will facilitate any analyses of recent changes in crayfish distribution to the compared to changes in land use . There is regular monitoring of the relative abundance of freshwater crayfish in the Rotorua Lakes by the University of Waikato.

NIWA manages an aquatic plants database which has information on aquatic plants in about 100 lakes. The database was set up in the 1970's and a number of locations have been visited more than once. The computer software which is used to analyse the data has been upgraded a number of times. Using the data collected about aquatic plants NIWA is able to perform the following analyses for a number of individual lakes:

- Aquatic plants species diversity
- Relative abundance of exotic versus native species
- The maximum depth vegetation grows to
- Whether the lake vegetation communities are stable or in a process of change

The data can also be combined to answer questions about aquatic plants in particular regions. Detail about the data collection methodology is summarized in the current monitoring and research section for potential indicator *FW8 Presence and extent of alien plant cover by waterbody ecotype.*

Methods

This indicator would use existing methodology and monitoring programmes, possibly with some extensions.

Reporting

The unit of reporting would depend on species involved. With blue duck it could be the estimated number of individuals.

Commentary

Indicator species should represent more than themselves. For many species their status and behaviour just reflects what is happening to them. This applies particularly to species which are subject to special management such as the black stilt. There is insufficient information about many species to know whether changes in their distribution and abundance reflect similar changes in other species. Species with naturally restricted distributions would not normally be considered as national indicator species.

The grebes (including dabchick) represent the degree of lacustrine(lake) natural character including natural riparian vegetation and natural hydrological regimes. Grebes are also sensitive to predation. The blue duck represents upland riverine natural character including the extent of natural riparian and catchment vegetation. Grebes and blue duck have good baseline data that can be derived from the OSNZ and Department of Conservation databases. The New Zealand dabchick is included within the IUCN Conservation Action Plan for Grebes (O'Donnell & Fjeldsa, 1997). That plan recommends implementing a monitoring programme for the New Zealand dabchick. It also recommends writing and implementing a species recovery plan in case dabchick numbers start to decline again. Both blue duck and grebes (including dabchick) could be used as indicator species subject to further discussion about their representativeness given their current limited geographical distribution.

Grey duck and crayfish (koura) are both important species but at this stage it would appear to be impractical to collect sufficient data on their relative abundance to allow them to be reported as national indicator species. Collier, Parkyn & Rabeni (1997) discuss whether koura perform a keystone species role in aquatic ecosystems, analyze alternative methods of estimating koura abundance and describe future koura research. The latter includes assessing the effects of catchment land use on koura. Depending of the outcomes of this research it may in future be appropriate to review the potential use of koura as an indicator species.

The presence of *Deleatidium* mayfly lavae is generally indicative of moderate to good water quality and a stony substrate. It is a very common and widespread genus that occurs over most of New Zealand. Changes in the percentage of sites with *Deleatidium* present could indicate trends in national stream and river water quality if the sampling sites are representative of New Zealand's rivers and streams. It is unclear whether this would represent changes in other species. It is also unclear whether this would provide information additional to that collected confirmed indicator *FW3 Macroinvertebrates in rivers*.

Declines in the extent of characean meadows represent a general decline in indigenous plant species in freshwater ecosystems due to invasive alien species and other habitat changes. As characean meadows are a community type this potential indicator is discussed as a separate indicator *% change in the extent of characean meadows (*refer to the commentary section in potential indicator *FW8 Presence and extent of alien plant cover*).

There appear to be no indigenous plant species that can be used directly as an indicator species. *Isoetes kirkii* was suggested as a possibility. It would not however, be suitable as an indicator species because:

- it was never particularly abundant in the North Island
- it has declined because of a decline in the condition of habitat requirements. These habitat reuqirements are not necessarily indicative of the requirements of a wider range of species.

FW 6. The number and percentage of threatened species in different IUCN threat categories.

Explanation

The IUCN status categories (IUCN, 1994) are as follows:

- Extinct (there is no reasonable doubt that the last individual has died).
- Extinct in the wild (the taxon is thought to be extinct in the wild, but is still present in either cultivation or in a zoo).
- Critically endangered (the taxon is facing an extremely high-risk of extinction in the wild in the immediate future).
- Endangered (the taxon is not critically endangered but is facing a very high-risk of extinction in the wild and the near future).
- Vulnerable (the taxon is not critically endangered or endangered but is facing a high-risk of extinction in the wild in the medium-term future).
- Lower risk (the taxon does not satisfy criteria for any of the above categories).
- Conservation dependent (these are taxa which are the focus of a continuing taxon specific or habitat specific conservation programme targeted towards the taxon in question. If this programmed ceased then the taxon would qualify for one of the threatened categories within a period of five years).
- near threatened (taxa which do not qualify for conservation dependent, but are close to qualifying for vulnerable status).
- least concern (taxa which do not qualify for conservation dependent or near threatened status).
- Data deficient (there is insufficient information to assess the risk of extinction. Listing a taxon here does not mean that it is threatened or of lower risk, but it does acknowledge the possibility that future research may show that a threatened classification is appropriate).
- Not evaluated (the taxon has not yet been assessed).

The criteria for each of these categories are in Appendix 1.

Issues

- New Zealand's biota is both highly distinctive and highly vulnerable to the adverse effects of habitat destruction and alien biota. Today many taxa have a threatened status.
- The distribution and population sizes of many indigenous species have been reduced. It is likely that this has reduced the genetic diversity of those species.

Policy goals

- Develop or maintain necessary legislation and/or other regulatory provisions for the protection of threatened species and populations (Convention on Biological Diversity).
- Ensure the survival of all indigenous species in their natural communities and habitats (Reserves Act, s3).
- Protect wildlife throughout New Zealand (Wildlife Act).

Current monitoring

The Department of Conservation maintains a database that identifies priorities for the conservation of New Zealand's threatened plants and animals. Molloy & Davis (1992) developed a set of 17 criteria (refer to Appendix 2) for the Department of Conservation to use in determining its priorities for actions to conserve threatened plants and animals. These criteria address the following 5 factors:

- Taxonomic distinctiveness
- Status of the species
- Threats facing the species
- Vulnerability of the species
- Human values

Panels of experts have been used to assess mosses, vascular plants, birds, fish, terrestrial invertebrates, reptiles and amphibians. Other taxonomic groups have not been assessed.

In 1994 (Tisdall, 1994) 403 species were included in categories; A (highest priority threatened species); B (second priority threatened species); and C (third priority threatened species).

A further 408 species were placed in categories I, O, M and X. Category X species are those which have not been sighted for a number of years but may still exist. Category I species are those for which little information exists, but based on existing evidence are considered to be threatened. Category O species are those which are threatened in New Zealand but are known to be secure in other parts of their range. Category M species are those which are rare or localized and of cultural importance to Maori. It is intended that future reviews of species ranking will be undertaken as required.

Methods

The implementation of this indicator would not be able to directly use the Department of Conservation database that identifies priorities for the conservation of New Zealand's threatened plants and animals. This is because the criteria used to compile the Department's database include a much wider range of matters than the status of individual species.

It may be possible for the review panels used by the Department to assess individual species against the IUCN criteria as well as the criteria the Department uses (Molloy & Davis, 1992) to prioritise species for conservation actions.

Reporting

The unit of reporting would be the number of taxa in each IUCN (and New Zealand) threat category. The data could be presented in the form of bar graphs.

Commentary

The IUCN classfication system suits continental areas. It does not address many of the special features of archipelagos such as New Zealand. In island systems many taxa naturally occupy extremely restricted habitats. This is certainly the case in New Zealand where a number of taxa naturally have a restricted distribution and relatively low numbers of individuals. De Lange & Norton (1997) give a number of examples for plants including:

- Plants that are to confined specific and uncommon substrates such as ultramafics (e.g. *Carex ophiolithica*) or calcareous substrates (e.g. *Clematis marmoraria).*
- Plants that are restricted to disturbed environments which can be uncommon in some landscapes (e.g. kakabeak).
- Plants that are restricted to specific environments (e.g. *Melicytus flexuosus* is restricted to sites with well drained, fertile soils with cold frosty winters and warm dry summers).
- Plants that are uncommon because of the specification resulting from recent evolution (e.g. *Myosotis* species).

In their evaluation of systems for ranking uncommon and threatened species de Lange & Norton (1998) state that a significant problem with the IUCN system is that it assumes that all uncommon species are threatened. In New Zealand this assumption is often not valid because many species can be naturally uncommon but under no immediate threat. de Lange & Norton propose an alternative system that recognises that not all uncommon species are threatened species. Their system also provides for taxa that are still nationally widespread but are in serious decline (e.g. cabbage tree). They state that while they focus on plants the system could be applied to all biota. Further development would be required before this system could be applied more generally, including to the freshwater environment.

At present the Department of Conservation uses criteria developed by Molloy & Davis (1992) to prioritize species for conservation action. As these criteria address a range of factors in addition to the status of individual species it is not appropriate to use them to report on the changes in the number of threatened species.

It is recommended that the proposed indicator be reworded as follows:
the number of taxa in IUCN and New Zealand threat categories.

In spite of the problems with using the IUCN categories it is appropriate that they be used for international reporting as they are the international standard for classifying threatened species. The revised indicator recognizes this and suggests that a complementary system be developed to meet New Zealand's specific requirements. As discussed in Froude (1998b) this system should also recognize and address the specific requirements of the New Zealand marine and freshwater environments. A modified de Lange & Norton system may provide the basis for a more appropriate New Zealand system.

FW 7. The condition and abundance of trout

Explanation

Trout were first introduced into New Zealand in the 1870s. They have since been introduced into most freshwater habitats of any size. Trout fishing is a very popular recreational activity. There is a comprehensive legislative framework and management structure to ensure that trout fisheries are managed appropriately. The success of trout has been to some extent, at the expense of indigenous freshwater fish species. Efforts to protect trout habitat have often benefited indigenous species as well.

Issues

Freshwater fisheries have been significantly damaged by habitat loss and degradation.

Policy goals

- Protect the habitats of trout and salmon (RMA, s7h).
- Protect the natural character of wetlands, rivers and lakes and their margins (RMA, s6a).
- Protect recreational freshwater fisheries (Conservation Act).

Current monitoring and research

Fish and Game Councils (and for the Taupo fishery, the Department of Conservation) are required to monitor sports fish populations and the conditions of ecosystems as habitats for sport fish (Conservation Act, s26Q(1)(a)). Councils use a variety of assessment techniques for trout, including:

- abundance and timing of spawning migrations as an indicator of population strength (using fish migration trapping)
- the relative abundance of different size classes of adult and sub adult trout in streams (using drift diving).
- The relative abundance of juveniles and some adult trout in streams (using electric fishing machines).

The Department of Conservation manages and monitors the Taupo trout fishery. The Department's programmes include:

a) Monitoring the use of the trout fishery in the Taupo Fisheries District. This programme monitors the number of anglers and angler catch rates in upland lakes and rivers. This provides the most accurate estimate of angling harvest.

b) Monitoring the quality of the trout fishery in the Taupo Fisheries District. This programme measures the size of the adult trout population, the size of the spawning runs in selected streams, the size and condition of fish at maturity, and juvenile trout numbers in selected streams. This is a long term programme with the first major survey being in 1950 –53. The scope and magnitude of the surveys have increased as the knowledge of the fishery has increased. Methods include acoustic surveys of Lake Taupo; fish migration trapping in some streams and rivers; some juvenile trapping; electric fishing at selected sites and escapement counts using drift diving and walking stretches of some rivers.

Commentary

The condition and abundance of trout tells us more about the effectiveness of the management of trout habitat (e.g. water quality) and trout population stocks, than about biodiversity. If this potential indicator is retained it would be more appropriately located within the water strand of the EPI Programme.

FW 8. Presence and extent of alien plant cover by waterbody eco-type

Explanation

Alien plant invasion is probably the most pervasive change to New Zealand's freshwater biodiversity. Invasive alien plants (eg. oxygenweeds,*(Lagarosiphon, Egeria, Elodea)* watercress, willows, sweetgrasses, and hornwort) replace indigenous plant communities, thereby reducing indigenous biodiversity. The extent of alien plant invasion in freshwater ecosystems has been invisible to most people and few resources have been allocated to systematic monitoring, containment, eradication and control. Howard-Williams et al (1987) discussed the impacts of invasive macrophytes in New Zealand inland waters.

Issues

- New Zealand is highly vulnerable to the adverse effects of alien species because it has an evolutionarily distinctive biota combined with a maritime climate and dynamic geological and geomorphic processes. Alien species threaten the survival of a number of indigenous taxa. They have also damaged and continue to damage, entire indigenous community structures and functioning in a number of locations.
- Less than10% of the original mosaic of wetland systems remains today. Many of the remaining wetlands have been degraded to varying degrees by invasions of alien plants, invertebrates, fish and waterfowl, modifications to hydrological regimes or barriers to fish migration. The loss of wetland extent and diversity is continuing.
- Most lowland river systems have been ecologically degraded by biological invasions, sediment/contaminant fluxes, channelization or the removal of floodplain connections.
- Many lakes (especially in lowland and coastal areas) have been degraded by eutrophication. Their fish communities are generally dominated by introduced species, and invasive exotic plant species are extensive in most lake systems.

Policy goals

- Prevent the introduction of, control or eradicate those alien species that threaten ecosystems, habitats or species (Convention on Biological Diversity, article 8).
- Contain and control plant and animal pests to improve habitat and species protection and retention (E2010).

- Ensure, as far is possible, the survival of all indigenous species of flora and fauna in their natural communities and habitats (Reserves Act ,s3).
- Introduced flora and fauna will be eradicated as far as possible (New Zealand National Parks General Policy).
- Preserve the natural character of wetlands, rivers and lakes and their margins(RMA, s6a)

Current monitoring and research

The Aquatic Plants Database was established in 1978 and is now managed by NIWA. It has data from approximately 100 New Zealand lakes. Many of the sites on the database have been revisited.

Data is generally collected using a rapid survey method (Clayton, 1983; Clayton, 1984). Ideally, there is a minimum of 25 profiles for each lake. These profiles follow the maximum slope gradient from the shore to the deepest depths where plants grow. These profiles are regularly spaced around the lake being surveyed.

Data is collected along a two metre wide band along each profile. It includes: the grid reference, maximum depth and estimated length of the profile; and the following information for each species:

- Minimum depth
- Maximum depth
- The maximum cover within a 2 x 2 m square from anywhere within its range
- Average cover within its range (cover is measured on a scale of 1 to 6 where 6 is dominant and 1 is patchy)
- Maximum height (if > 0.5m) in the profile
- Estimated average height

Statistical and other analyses are used to derive the following information for each lake:

- Species list
- Depth range for each species
- Total number of profiles with each species
- Minimum, maximum and typical depths for each species
- Maximum and average cover for each species
- The % dominance of exotic versus native species
- Relative % cover of different species
- An assessment of whether the plant communities are stable or changing (derived through comparisons over time)
- Stylized profiles of the lake plant communities

A NIWA research programme on aquatic plant seedbanks intends to provide a picture of vegetation changes over time in different lakes. In this programme sediment cores will be taken from a range of waterbodies. For each core the percentage of different species of seed at different depths will be assessed. This will help to identify the resilience of a lake and its ability to recover from perturbation.

There are local aquatic plant surveillance programmes that seek to identify new invasive plant species in freshwater lakes. An example is the regular monitoring around boat ramps in Lake Waikaremoana (part of Te Urewera National Park).

Commentary

Two aspects relating to freshwater alien plants should be monitored:

- the distribution of troublesome alien plant species (eg. *Lagarosiphon,Egeria, Hydrilla,* hornwort)
- changes in the relative extent of indigenous and alien plant communities, particularly in lakes.

The first aspect would require regular surveillance of rivers and lakes to determine changes in the distribution of invasive alien plant species. While this is not technically difficult (apart from needing to be able to identify the problem plants) there is no systematic monitoring of alien plants in freshwater systems. This would require that alien plant monitoring and management responsibilities in freshwater systems be clarified. General estimates of the distribution of invasive alien plant species could be derived from the Aquatic Plants Database and the knowledge of experts including regional council biosecurity officers.

It would be appropriate to have a single indicator addressing the distribution of troublesome alien plant and animal species. This would be equivalent to the complementary indicators developed in the terrestrial biodiversity and marine environment strands of the EPI Programme.

The second aspect would provide information about the condition of aquatic plant communities and changing relationships between indigenous plant communities and the alien plant invaders. The NIWA Aquatic Plant Database can be used to identify for 100 lakes:

- the relative dominance of alien and indigenous plant species;
- the relative abundance of individual species; and
- whether the plant communities are stable or in a process of change.

It would be necessary to clarify how representative these 100 lakes are; and whether a more nationally representative suite of waterbodies would be desirable for the effective implementation of this potential indicator.

A complementary approach would be to measure the percentage change in the extent of characean communities. These are indigenous plant communities. In lakes their natural habitat is below the indigenous shallow water communities dominated by *Myriophyllum* and *Potamageton* species. Characean and other indigenous species also occur in some deeper soft sediment rivers. Characean meadows are probably the most desirable plant communities for freshwater lakes. There are minimal management problems; they provide a diversity of habitats for indigenous fauna; they stabilize sediments, clear water and decrease water nutrient levels (Clayton & Tanner, 1987). A change in the extent of characean communities is a direct measure of changes in a lake's condition.

As characeans are light limited the maximum depth they grow to is limited by water clarity. A decline in their maximum depth in a lake reflects both medium and long term reductions in that lake's water clarity. Characeans are also out-competed in shallow waters by invasive alien species such as *Lagarosiphon* and *Egeria*. These alien species are however, pressure limited and so are not able to grow to the same depths as the characean species. A decline in the extent of characean species therefore reflects one or both of a decline in habitat conditions (water clarity); and competition from invasive plant species.

As with the potential indicator addressing the relative extent of indigenous dominated communities and alien dominated communities the Aquatic Plant Database could provide the base information for this indicator.

It should be clarified whether alien plant invasion in wetlands is addressed in this indicator or as part of the indicator addressing wetland extent and condition.

Possible revised potential indicators are:
- The distribution of identified invasive freshwater alien (plant) species
- The relative extent of indigenous plant communities and alien dominated plant communities in representative lakes
- The extent of characean communities in representative lakes (This is also a general condition indicator)

FW 9. The number and types of alien fauna species present by waterbody eco-type

Explanation

This proposed indicator seeks to identify the pressures on indigenous freshwater ecosystems caused by alien fauna. Various species of alien fauna have significantly modified many indigenous freshwater ecosystems, especially their indigenous fish components. Exotic fish species have displaced or become important predators of some native fish species.

The most widespread alien fish species are brown and rainbow trout. Trout (especially brown trout) are both predators and competitors for food and territory with native fish species (Taylor & Smith, 1997). Trout may compete with blue ducks for food (Towers, 1996), and predate a number of invertebrate species including the freshwater crayfish. McDowell (1996) notes that freshwater crayfish have been reduced to such an extent that it is difficult to find them in areas where trout are present. Townsend & Crowl (1991) observe that although land use has affected indigenous fish populations, the main factor that explains their extreme patchiness is the presence or absence of brown trout.

Noxious coarse fish species (e.g. rudd, perch and European carp) are becoming more widespread. These species threaten native fish species, general stream ecology and in some cases the waterways themselves. For example, carp are mud feeders. This behaviour can undermine stream banks, make the water turbid and cause significant damage to aquatic ecosystems (Taylor & Smith, 1997).

Other indigenous displacements arise from the impacts of invasive introduced waterfowl (eg. mallard duck, Canada geese, black swan) and molluscs (eg. *Physa*, *Physastra*).

Issues

- New Zealand is highly vulnerable to the adverse effects of alien species because it has an evolutionary distinctive biota combined with a maritime climate and dynamic geological and geomorphic processes. Alien species threaten the survival of a number of indigenous taxa. They have also damaged and continue to damage, entire indigenous community structures and functioning in a number of locations.
- <10% of the original mosaic of wetland systems remain today. Many of the remaining wetlands have been degraded to varying degrees by invasions of alien plants, fish and waterfowl, modifications to hydrological regimes or barriers to fish migration. The loss of wetland extent and diversity is continuing.
- Most lowland river systems are ecologically degraded by biological invasions, sediment/contaminant fluxes, channelization or the removal of floodplain connections.
- Many lakes (especially in lowland and coastal areas) have been degraded by eutrophication. Most lake fish communities are dominated by introduced species, and invasive exotic plant species are extensive in most lake systems.

Policy goals

- Prevent the introduction of, control or eradicate those alien species that threaten ecosystems, habitats or species (Convention on Biological Diversity, article 8).
- Contain and control plant and animal pests to improve habitat and species protection and retention (E2010).
- Ensure, as far is possible, the survival of all indigenous species of flora and fauna in their natural communities and habitats (Reserves Act, s3).
- Introduced flora and fauna will be eradicated as far as possible (New Zealand National Parks General Policy).
- Preserve the natural character of wetlands, rivers and lakes and their margins(RMA, s6a)
- Noxious fish are subject to containment and eradication (Freshwater Fisheries Regulations).
- Preserve all indigenous freshwater fisheries and protect freshwater fish habitats (Conservation Act, s6ab).

Commentary

This potential indicator appears to require counting the number of alien species present in different waterbody types. Results could depend on the intensity of the sampling, especially if invertebrates are sampled. The total number of alien species may not be a particularly meaningful indicator because a few species may have a major effect and a large number of the species may have a minor effect.

An appropriate alternative indicator could be *the distribution of invasive alien aquatic fauna* or *the distribution of identified invasive alien species*. The second option incorporates part of the revised indicator FW8. This indicator should be further discussed in the pests and weeds strand of the EPI Programme.

FW 10. The number of the eco types/waterbodies free from alien species.

Explanation

Very few freshwater waterbodies are free from alien species. As such few relatively unmodified indigenous freshwater communities remain, especially in lowland areas. Many policies address the protection of natural character and the eradication/control of alien species.

Issues

- New Zealand is highly vulnerable to the adverse effects of alien species because it has an evolutionary distinctive biota combined with a maritime climate and dynamic geological and geomorphic processes. Alien species threaten the survival of a number of indigenous taxa. They have also damaged and continue to damage, entire indigenous community structures and functioning in a number of locations.
- Less than <10% of the original mosaic of wetland systems remain today. Many of the remaining wetlands have been degraded to varying degrees by invasions of alien plants, fish and waterfowl, modifications to hydrological regimes or barriers to fish migration. The loss of wetland extent and diversity is continuing.
- Most lowland river systems are ecologically degraded by biological invasions, sediment/contaminant fluxes, channelization or the removal of floodplain connections.
- Many lakes (especially in lowland and coastal areas) have been degraded by eutrophication. Most lake fish communities are dominated by introduced species, and invasive exotic plant species are extensive in most lake systems.

Policy goals

- Prevent the introduction of, control or eradicate those alien species that threaten ecosystems, habitats or species (Convention of Biological Diversity, article 8).
- Contain and control plant and animal pests to improve habitat and species protection and retention (E2010).
- Ensure, as far is possible, the survival of all indigenous species of flora and fauna in their natural communities and habitats (Reserves Act ,s3).
- Introduced flora and fauna will be eradicated as far is possible (New Zealand National Parks General Policy).
- Preserve the natural character of wetlands, rivers and lakes and their margins(RMA, s6a)
- Noxious fish are subject to containment and eradication (Freshwater Fisheries Regulations).
- Preserve all indigenous freshwater fisheries and protect freshwater fish habitats (Conservation Act, s6ab).

Commentary

As written this indicator would be very difficult to measure because it requires much sampling to confirm that all alien species are absent. Given the pervasiveness of invasive alien biota and their ecological impacts, it would be more appropriate to monitor the number of waterbodies that are free from invasive alien species

A suggested alternative indicator is *the number of waterbodies free from invasive alien plants, vertebrate and mollusc species*. This revision makes the indicator workable because it has narrowed its scope. As part of the indicator design a list of invasive species could be determined along with a process for adding new species.

The indicator could be reported by waterbody type and/or environmental domain. The methodology for this revised indicator could include the use of the Aquatic Plants and Freshwater Fish Databases, information from experts and general surveillance monitoring carried by management agencies. As it is more difficult to prove absence than presence, criteria defining absence would be desirable.

FW11. The length, or percentage of length of rivers that are unmodified by type of modification, by order, by eco type

Explanation

There are a variety of modifications (e.g. impoundments, barriers, flow modifications, channelization, stop banking, clearance of riparian vegetation) that act as pressures on freshwater biodiversity. This indicator seeks to identify the extent of these pressures. The indicator is policy relevant in terms of both the protected area legislation and the Resource Management Act 1991 natural character provisions.

Issues

Most lowland river systems are ecologically degraded through biological invasions, sediment/contaminant fluxes, channelization or the removal of floodplain connections.

Policy goals

- Preserve all indigenous freshwater fisheries and protect recreational freshwater fisheries and freshwater fish habitats (Conservation Act, s6ab).
- Preserve the natural character of rivers and their margins (RMA,s6a).
- Protect the habitat of trout and salmon (RMA,s7h).
- Preserve representative examples of all classes of natural ecosystems (Reserves Act, s3).

Current monitoring

In the mid 1980s Fisheries Research Division of the Ministry of Agriculture Fisheries coordinated out regional assessments of modifications to waterways. These were qualitative assessments.

Some regional councils may have inventories of some modifications to rivers in their regions.

Commentary

The scope of modifications addressed by this indicator would need to be defined. The working group focused on structural modifications, with alien species impacts being addressed by other indicators. It may be appropriate to address modifications resulting from contaminants, and changes in sediment and nutrient regimes. These would be more difficult to address than an inventory of structural changes, but would give a more complete picture. While it is likely that better data will be available on modifications to larger rivers, modifications to small rivers and tributaries can also be ecologically damaging.

Further work would be required to establish the extent and quality of data needed to effectively implement this indicator. It would most appropriately be a stage 2 indicator.

FW12. The number and percentage of rivers affected by artificial barriers to fish passage

Commentary

This is a subset of indicator FW11. The ideal measure would be the amount of freshwater habitat unavailable to each species of migratory indigenous fish due to artificial barriers. This could be one of the items reported in FW11.

FW13. The percentage of water eco types remaining today that are legally protected, by type of protection

Explanation

This indicator seeks to measure progress towards improving the representativeness of protected freshwater ecosystems in New Zealand. The type of protection is included because of the difficulty of effectively protecting freshwater ecosystems. Protection is unambiguous when the catchment of the protected freshwater ecosystem is also protected. This generally applies to upland sections of waterbodies. Relatively few lowland sections of waterbodies are legally protected. Even fewer have catchments and/or ripanan margins that are also protected. The type of legal protection can vary from a water conservation order (protects the water) to a scenic reserve (protects the bed and biota of the waterbody). Most freshwater ecosystem types are under-represented in the protected area network. For example, only 4% of the remnant wetlands in Canterbury are formally protected (Sullivan, 1998).

Issues

Many indigenous freshwater habitat types and ecosystems, especially lowland freshwater ecosystems, are under represented in New Zealand's network of protected areas.

Policy goals

- Preserve representative samples of all classes of natural ecosystems and landscapes (Reserves Act, s3).
- Protect representative examples of all indigenous ecosystems(E2010).
- Preserve the natural character of wetlands, rivers and lakes and their margins (RMA, s6a).
- Protect significant indigenous vegetation and significant habitats of indigenous fauna (RMA,s6c).
- Preserve all indigenous freshwater fisheries and freshwater fish habitats (Conservation Act, s6ab).
- Preserve representative examples of all types of wetlands (Wetland Management Policy).

Commentary

This is a policy relevant potential indicator. The data on which areas are protected are easy to collect and monitor. More difficult is the measurement of the total area of each aquatic ecosystem type. It is appropriate to identify the type of protection (e.g. waterbody and catchment within a protected area; bed of waterbody legally protected in whole or part; water conservation order).

Geothermal ecosystems have a further complication. While the ecosystem itself can be contained completely within a protected area, bores can be drilled into the underlying geothermal reservoir from outside the protected area. The abstraction of heat and/or fluid can adversely affect the geothermal ecosystems contained within the reserve. Reporting on geothermal ecosystems would need to address both the legal protection of ecosystems on the ground surface and protection of the underlying aquifer from the damaging effects of heat and/or fluid extraction. The latter may be done by way of rules in regional plans.

FW14. The percentage of freshwater margins with legal and unobstructed public access

Policy goals

- Maintain and enhance public access to and along lakes and rivers (RMA,s6d).
- Preserve public access to and along lake shores and river banks (Reserves Act,s3)

Existing monitoring and databases

District councils are required under S.35(5) of the RMA to have maps that show the extent of esplanade reserves and many of the other reserves in their districts. The Department of Conservation has maps that show the location of marginal strips and other public reserves adjoining waterbodies.

Commentary

This indicator would most appropriately be addressed as part of the freshwater strand of the EPI Programme or combined with the equivalent potential indicator from the marine environment strand.

At the national level it would be most appropriate to measure the extent of water margin legal protection. The measurement of obstructions can be subjective and would be more appropriate for district level monitoring. It is suggested that this indicator be reworded*: the percentage of freshwater margins where there is legal public access.*

It should be recognised that while many legal mechanisms that provide for public access also (or primarily) protect and enhance ecological values, this particular indicator is not one that addresses biodiversity matters.

Suggested indicators that will not be further developed

Suggested indicator considered	Type	Reasons for not developing the indicator
1. The phylogenetic diversity/evolutionary distinctiveness of selected freshwater taxonomic groups	State	This indicator could usefully compare the phylogenetic diversity between sites, and compare temporal changes in phylogenetic diversity for regions as it would record distribution changes. It would be relatively insensitive to temporal changes at the national level because it would only record extinctions and new species (the latter usually reflecting taxonomic review). Total extinctions are rare in freshwater ecosystems and so this indicator would mainly show improved taxonomy.
2. The genetic diversity of valued introduced species	State	It would not be practical to implement this indicator because extensive sampling and analysis would be required to determine the range of genotypes within selected introduced species. It is questionable whether this would be a policy relevant indicator at this time. Even if it could be considered policy relevant, it is possible that this matter would be better addressed through an alternative mechanism.
3. The evolutionary/phylogenetic diversity of selected groups of valued introduced species.	State	As this indicator could easily be increased by introducing new species, the loss of a few distinctive varieties would have little impact on the outcome. It is questionable whether this potential indicator is policy relevant at this time.
4. The number of new alien taxa releases	Pressure	Most new alien taxa releases are not officially sanctioned. It is not necessarily the number of new releases that are a problem. The potential impacts are most significant.
5. The amount of New Zealand covered by RMA plans that are intended to achieve appropriate catchment management	Response	This would probably be a subjective measure. The provisions in plans may not be reflected in outcomes on the ground.
6.% riparian margins in indigenous vegetation	State, pressure	The development of a riparian margin condition indicator is a long-term project in the freshwater strand of the EPIP.
7.% potential whitebait habitat that is suitable for whitebait	State	This is a variation on any indicator addressing riparian margin condition and would probably

spawning		the best addressed as part of that work.

8. % New Zealand with regional plans designed to protect freshwater fish habitat.	Response	While this would be policy relevant it could be subjective. Plan intentions may not be reflected in outcomes on the ground.
9. The number of freshwater fisheries habitat restoration programmes	Response	It is questionable whether a specified number of programmes is significant. It is unclear what constitutes a "programme" and at what stage it would be completed.
10. Whitebait catch per unit effort on selected rivers.	Pressure	This is an agency responsibility and may not directly reflect biodiversity outcomes.
11. The harvest rates for whitebait, eels and trout	Pressure	It would be appropriate to include eels in the equivalent indicator in the marine environment strand of the EPIP. While the harvest of eels occurs in freshwater systems, eels do migrate to the sea for part of their life cycle. Commercial eel harvest is addressed in the fisheries quota management system. The harvest of whitebait was discussed in 10 above. Potential trout indicators were discussed in FW7.
12. The number of RMA applications for potentially damaging activities in freshwater ecosystems	Pressure	The number of applications is not the number approved. It is the potential impacts that are significant rather than the number of applications. It would be more informative to either measure the pressures directly and/or measure changes in freshwater condition.

References

Boothroyd,I.K.G; Forch,E.C. 1998. Macroinvertebrate monitoring: data collection and storage. In: the use of macroinvertebrates and water management. A draft paper prepared by The Ministry for the Environment Macroinvertebrate Working Group.

Clayton, J.S. 1983. Sampling freshwater macrophyte communites. In: Biological methods for water quality surveys. *Water and Soil Technical Publication 54.*

Clayton, J.S. 1984. Quck survey of aquatic plants in Lake Wanaka. Pp 211-226. In: Design of Water Quality Surveys. Proceedings of a symposium. *Water and Soil Technical Publication 63.*

Clayton, J.S. 1989. Monitoring aquatic plants in lakes, Pp 136-145. In: Proceedings of a Symposium on Environmental Monitoring in New Zealand, May 1988.

Clayton, J.S; Tanner, C.C. 1987. Selective control of submerged aquatic plants to enhance recreational uses of water bodies. *Verhandlungen der Int Vereingung fver Theoretische & Angewandte Limnology 23: 1518-1521*

Collier,K. 1993. Review of the status, distribution and conservation of freshwater invertebrates in New Zealand. *New Zealand Journal of Marine and Freshwater Research*: 27: 339-356.

Collier,K.J; Parkyn,S.M.; Rabeni, C.F. 1998. Koura: a keystone species. *Ichthyofile*. pp 25-27.

Cromarty,P; Scott,D.A. (compilers) 1996. *A Directory of Wetlands in New Zealand.* Department Of Conservation: Wellington.

De Lange,P.J.; Norton,D.A. 1998. Revisiting rarity: a potential perspective on the meanings of rarity and the classification of New Zealand's uncommon plants. pp.145-160 In: Ecosystems, Entomology and Plants. *Royal Society of New Zealand Miscellaneous Series, No. 48.*

Frey,D.G.1977. Biological integrity of water- an historical approach. Pp. 127-140 In: The Integrity of Water. (editors) R.K. Ballantine & L.J. Guarraia. US EPA: Washington D.C..

Froude,V.A. 1998a. A summary of New Zealand terrestrial and freshwater biodiversity monitoring and databases. A technical paper prepared for the Ministry for the Environment as part of Environmental Performance Indicators Programme. Pacific Ecologic Resource Management Associates.

Froude,V.A. 1998b. The New Zealand environmental performance indicators programme: an analysis of potential indicators of marine biodiversity. *EPIP Technical Paper No.44*. Ministry for the Environment: Wellington.

Froude,V.A. 1998c. The New Zealand environmental performance indicators programme: an analysis of potential indicators of terrestrial biodiversity. *EPIP Technical Paper No.47.* Ministry for the Environment: Wellington.

Froude,V.A. 1998d. The New Zealand environmental performance indicators programme: an analysis of potential fishing impacts indicators. *EPIP Technical Paper No.43.* Ministry for the Environment: Wellington.

Howard-Williams, C; Clayton, J.S: Coffey, B.T; Johnstone, I.M. 1987. Macrophyte Invasions. In: Inland Waters of New Zealand. (Editor) A.B. Viner. DSIR Bulletin 241.

Hughes,R.M.; Kautmann,P.R.; Herlihy,A.T.; Kincaid,T.M.; Reynolds,L.; Larsen,D.P.;1998. A process for developing and evaluating indices of fish assemblage integrity. *Canadian Journal of aquatic science* 58; 1618-1631.

IUCN, 1994. IUCN red list categories. IUCN: Gland.

Ministry for the Environment, 1997. Environmental performance indicators -- proposals for air, freshwater and land. Ministry for the Environment: Wellington. 158p + appendices.

Ministry for the Environment, 1998a. Environmental performance indicators -- proposals for terrestrial and freshwater biodiversity. Ministry for the Environment: Wellington.

Ministry for the Environment, 1998b. Environmental performance indicators -- confirmed indicators for air, freshwater and land. Ministry for the Environment: Wellington. 20p.

Ministry for the Environment Macroinvertebrates Working Group, 1998. The use of macroinvertebrates in water management. Draft report for the Ministry for the Environment.

O'Donnell,C.;Fjeldsa,J. (compilers) 1997. Grebes -- status survey and conservation action plan. IUCN/SSC grebe specialist group. IUCN: Gland,Switzerland and Cambridge,U.K. 59p.

Richardson,J. 1993. Database tops 10,000 records. *Water and Atmosphere*. 2(3): 23-24.

McDowall,R.M. 1968. Interactions of the native and alien faunas of New Zealand and the problems of fish interactions. *Transactions of the American Fisheries Society.* 97: 1 -11.

McDowall,R.M. 1996. Biodiversity in New Zealand freshwater fishes, and the role of freshwater fishes as indicators of environmental health in New Zealand freshwaters. NIWA consultancy report no. MFE 70502. 86p.

McDowall,R.M. 1997. New native fish found. *Fish and Game New Zealand.*

Molloy,J.; Davis,A. 1992. Setting priorities for the conservation of New Zealand's threatened plants and animals. First edition. Department of Conservation: Wellington.

Norse,E.A. (editor) 1994. Global marine biological diversity: a strategy for building conservation into decision-making. Island Press: Washington D.C. 383p.

Quinn,J.M.; Cooper,A.B.; Davies-Colley,R; Rutherford,J.C.; Williamson,R.B. 1997. Land use effects on habitat, water quality, periphyton and benthic invertebrates in Waikato New Zealand hill country streams. *New Zealand Journal of Marine and Freshwater Research*. 31(5): 579-597.

Quinn,J.M.; Hickey,C.W. 1990. Characterization and classfication of benthic invertebrate communities in 88 New Zealand rivers in relation to environmental factors. *New Zealand Journal of Marine and Freshwater Research*. 24: 387-409.

Rabini,C.F.; Collier,K.J.; Parkyn,S.M.; Hicks,B.J. 1997. Evaluating techniques for sampling stream crayfish (*Paranephropus planifrons*) *New Zealand Journal of Marine and Freshwater Research.* 31(5): 693-700.

Smith,P.J. 1994. Genetic diversity of marine fisheries resources: possible impacts of fishing. *FAO Fisheries technical paper 344.* 53p.

Stark,J.D.; 1993. Performance of the Macroinvertebrate Community Index: effects of sampling method, sample replication, water depth, current velocity, and substratum on index values. *New Zealand Journal of Marine and Freshwater Research.* 27: 463-478.

Stark,J.D. 1998. SQMCI: a biotic index for freshwater macroinvertebrate coded abundance data. *Journal of Marine and Freshwater Research*. 32: 55-66.

Sullivan, B. 1998. Public perceptions of wetlands; implications for wetland conservation and management; M. Applied Science Thesis: Lincoln University.

Thorsen, M. 1998. Determination of a standardised methodology for long-term monitoring of mainland *Leiopelma* specieis. A report prepared for the Department of Conservation.

Taylor,R.; Smith,I. 1997. The state of New Zealand's environment, 1997. Ministry for the Environment: Wellington.

Tisdall,C.(compiler) 1994. Setting priorities for conservation of New Zealand's threatened plants and animals. Second edition. Department of Conservation: Wellington.

Towers,D. 1996. Diet overlap between coexisting populations of native blue ducks and introduced trout: assessing the potential for competition. Unpublished Ph.D. thesis. Massey University: Palmerston North.

Townsend,C.R; Crowl,T.A. 1991. Fragmented population structure of a native New Zealand fish: an effect of introduced trout? *Oikos*. 61: 347-354.

Glossary

Alien species: species that are not indigenous to New Zealand.

Biological diversity: "the variability among living organisms from all sources including, inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are a part. This includes diversity within species, between species and of ecosystems." (Convention on Biological Diversity).

Biological Integrity: this is the ability to support and maintain a balanced, integrated, adaptive community of organisms having a composition, diversity and functional organization comparable with natural habitats of the region (Frey, 1977). Hughes et al (1998) define natural habitats as ones of minimal human disturbance or pre-Columbus (USA) condition. These natural habitats are benchmarks only and may not now be achievable.

Endemic: endemic taxa are only found naturally in the location being referred to. E.g. kiwi are endemic to New Zealand.

Freshwater ecosystems: for the purpose of the EPI Programme these include: rivers, lakes, freshwater wetlands, geothermal ecosystems and underground aquifers.

Indigenous: indigenous taxa occur naturally in the location being referred to and may also occur naturally in other locations. E.g. Australasian bittern are indigenous to New Zealand and they occur naturally in some other countries.

Keystone species: these are species whose activities are critical to the structure of the community in which they live.

Marine ecosystems: for the purpose of the EPI Programme these include all areas below mean high water springs out to the boundary of the exclusive economic zone. Estuarine saltmarsh communities are included even if they are above mean high water springs.

Macroinvertebrate community index (MCI) (for rivers): this is calculated from presence/ absence data for the different macroinvertebrate taxa. It does not take the relevative abundance of different macroinvertebrate taxa into account.

Naturalised species: alien species that have become established in the wild.

Macrophyte: rooted aquatic plant

QMCI: this is a variant of the macroinvertebrate community index. It takes account of abundance by weighing the taxon scores according to the percentage abundance of each scoring taxon.

SQMCI: this is a variant of the macroinvertebrate community index. It uses six abundance classes to give a semi quantitative estimate of relative abundance.

Taxon: (plural=taxa) a taxon is a unit of classification that extends below the species level to include sub-species and varieties. In this report this does not include varieties developed for the horticultural industry.

Terrestrial ecosystems: for the purpose of the EPI Programme this includes natural areas above mean high water springs excluding freshwater ecosystems, and estuarine saltmarsh communities above mhws. It includes terrestrial coastal habitats such as dunelands.

Appendix 1: IUCN Criteria for Species Status Categories

Extinct

A taxon is extinct where there is no reasonable doubt that the last individual has died.

Extinct in the wild

A taxon is extinct in the wild when it is known only to survive in cultivation, in captivity or as a naturalised population well outside its past range. A taxon is presumed to be extinct in the wild when exhaustive surveys in known and/or expected habitats, at appropriate times, throughout its historical range, have failed to record an individual.

Critically endangered

A taxon is critically endangered when it is facing an extremely high risk of extinction in the wild in the immediate future as defined by any of the following criteria:

1. An observed, estimated, inferred or suspected population reduction of at least 80% over the last ten years or three generations, whatever is the longer.
2. A population reduction of at least 80%, projected or suspected to be met within the next ten years or three generations, which ever is the larger.
3. The extent of occurrence is estimated to be less than 100km² or the area of occupancy is estimated to be less than 10km² and estimates indicate any two of the following apply:
   - there are severely fragmented populations or it exists at only one location;
   - there is continuing decline in the extent of occurrence, area of occupancy, extent and/or quality of habitat, number of locations, and number of mature individuals;
   - there are extreme fluctuations in any of the extent of occurrence, the area of occupancy, the number of locations, and the number of mature individuals.
4. The population is estimated to number less than 250 individuals and there is a continuing decline of at least 25% within three years or one generation, whatever is longer:
   or there is a continuing decline with severely fragmented sub populations;
   or all individuals are in one single sub population.
5. The population is estimated to number less than 50 mature individuals.
6. Quantitative analysis shows that the probability of extinction in the wild is at least 50% within ten years or three generations, which ever is the longer.

Endangered

A taxon is endangered when it is not "critically endangered" but is facing a very high-risk of extinction in the wild in the near future as defined by any of following criteria:

1. An observed, estimated, inferred or suspected population reduction of a least 50 percent over the last ten years or three generations, whichever is the longer.
2. A population reduction of at least 50 percent, projected or suspected to be met within the next ten years or three generations, whichever is the longer.
3. The extent of occurrence is estimated to be less than 5 000km² or area of occupancy estimated to be less than 500km² and estimates indicate any two of the following apply:
   - severely fragmented populations or populations at less than 5 locations;
   - continuing decline in the extent of occurrence, the area of occupancy, the area and/or quality of habitat, the number of sub populations, and the number of mature individuals;
   - extreme fluctuations in any of extent of the occurrence, the area of occupancy, the number of sub populations, and the number of mature individuals.
4. The population is estimated to number less than 2500 individuals and there is either:
   - a continuing decline of at least 20% within five years or two generations, whichever is longer
   - or there is a continuing decline in the numbers of mature individuals in the population because of severe fragmentation or all individuals are from one sub-population.
5. The population is estimated to number less than 250 mature individuals.
6. Quantitative analysis shows that the probability of extinction in the wild is at least 20 percent within 20 years, or five generations, whichever is the longer.

Vulnerable

A taxon is vulnerable when it is not critically endangered or endangered but is facing a high-risk of extinction in the wild in the medium-term future as defined by any of the following criteria:

1. There is a population reduction of the least 20 percent over the last ten years or three generations, whichever is the longer.
2. There is a projected population reduction of the least 20 percent for the next ten years, or three generations, whichever is the longer.
3. The extent of occurrence is estimated to be less than 20 000km² or the area of occupancy is estimated to be less than 2000km² and estimates indicate any two of the following apply:
   - there are severely fragmented populations or populations are at less than ten locations;
   - there is a continuing decline of any of the extent of occurrence; the area of occupancy; the area and/or quality of habitat; the number of sub populations and the numbers of mature individuals;
   - extreme fluctuations in any of area of occurrence, the area of occupancy, the number of sub-populations, and the number of mature individuals.
4. The population is estimated to number less than 10 000 mature individuals and there is either;

- a continuing decline of least ten percent within ten years of three generations, whichever is longer
- or there is a continuing decline in the numbers of mature individuals and the population structure.

5. The population is estimated to number less than 1000 mature individuals.
6. The population is characterized by an acute restriction in its area of occupancy(usually less than 100km²) or the number of locations (typically less than 5).
7. Quantitative analysis shows that the probability of extinction in the wild is at least ten percent within 100 years.

Lower risk

A taxon is lower risk where does not satisfy the criteria for critically endangered, endangered or vulnerable taxa. There are three sub categories of lower risk taxa:

1. *A conservation dependent* taxon is the focus of continuing taxon specific or habitat specific conservation programmes. The cessation of these programmes would result in the taxon qualifying for one of the threatened categories within five years
2. *A near threatened* taxon does not qualify as being *conservation dependent* but it is close to being of vulnerable status.
3. *A least concern* taxon does not qualify as being *conservation dependent* or *near threatened*.

Data deficient

This is when there is insufficient information to assess the risk of extinction for a particular taxon.

Appendix 2: The Criteria used by the Department of Conservation to Determine its Threatened Species Conservation Work

(from Tisdall, 1994, Molloy & Davis, 1992)

DISTINCTIVENESS

A. TAXONOMIC DISTINCTIVENESS:

5 Only one family in the order, or one genus in the family
4 Only one species within the genus
3 Recognised at species level; genetically and/or morphologically highly distinct from other members of the genus
2 Recognised at species level; morphologically and genetically quite similar to related species
1 Recognised at subspecies level

Note: Select the highest score that applies to each case

STATUS

A. NUMBER OF POPULATIONS:

5 Only one known
4 Only two known
3 From 3 to 4 known, or unknown but suspected to be small
2 From 5 to 10 known
1 More than 10 known, or unknown but suspected to be large

B. MEAN POPULATION SIZE:

Vertebrates, except Reptiles, Amphibians, and Fish:

5 Less than 50
4 From 50 to 100, or unknown but suspected to be small
3 From 100 to 500
2 From 500 to 1000
1 More than 1000, or unknown but suspected to be large

Vertebrates, except Reptiles, Amphibians, and Fish:

5 Less than 50, or area <0.25 ha
4 From 50 to 100, or area 0.25-1 ha, or unknown but suspected to be small
3 From 100 to 500, or area 1-10 ha
2 From 500 to 1000, or area 10 to 100 ha
1 More than 1000, or area >100 ha, or unknown but suspected to be large

Plants:

5 One plant or area <1 sq m
4 From 2 to 10 plants, or area 1-10 sq m, or unknown but suspected to be small
3 From 11 to 50 plants, or area 10 to 100 sq m
2 From 50 to 500 plants, or area 100-1000 sq m
1 Greater than 500 plants, or area >1000 sq m, or unknown but suspected to be large

C. LARGEST POPULATION:

Vertebrates, except Reptiles, Amphibians, and Fish:

5 Less than 50
4 From 50 to 100, or unknown but suspected to be small
3 From 100 to 500
2 From 500 to 1000
1 More than 1000, or unknown but suspected to be large

Invertebrates, Reptiles, Amphibians, and Fish:

5 Less than 50, or area <0.25 ha
4 From 50 to 100, or area 0.25 ha, or unknown but suspected to be small
3 From 100 to 500, or area 1-10 ha
2 From 500 to 1000, or area 10-100 ha
1 More than 1000, or area >100 ha, or unknown but suspected to be large

Plants:

5 One plant or area <1 sq m
4 From 2 to 10 plants, or area 1-10 sq m, or unknown but suspected to be small
3 From 11 to 50 plants, or area 10-100 sq m
2 From 50 to 500 plants, or area 100-1000 sq m
1 Greater than 500 plants, or area >1000 sq m, or unknown but suspected to be large

D. GEOGRAPHIC DISTRIBUTION:

5 Total range <10km^2
4 Found only in single ecological district
3 Found only in either North or South Island, or either two or three ecological districts
2 Found only in New Zealand
1 Occurs outside New Zealand

E. CONDITION OF LARGEST POPULATION:

5 Very poor
4 poor
3 Marginal
2 Moderate
1 Healthy

F. POPULATION DECLINE RATE:

5 Total wild population presently declining at a rate which is likely to cause the taxon to become extinct in the short-term (10-15 years)
4 Total wild population presently declining at a rate which is likely to cause the taxon to become extinct in the medium-term (15-25 years), or unknown but suspected to be declining rapidly
3 Total wild population presently declining at a rate which is like to cause the taxon to become extinct in the longer-term (25-50 years), or unknown but suspected to be declining at a moderate rate.
2 Total wild population presently showing very slight decline which is not expected to threaten the survival of the taxon in the next 50 years
1 total wild population stable or increasing

THREATS

A. LEGAL PROTECTION OF HABITAT:

5 No legal protection of any site
4 Informal protection at one or several sites
3 Long-term legal protection for at least one site
2 Long-term legal protection for several sites
1 Long-term legal protection at most or all sites

B. HABITAT LOSS RATE:

5 All remaining breeding grounds/occupied habitat likely to be destroyed in less than 10 years
4 Over half of the remaining breeding grounds/occupied habitat likely to be destroyed in less than 10 years
3 Between 25 and 50% of the remaining breeding grounds/occupied habitat likely to be destroyed in less than 10 years
2 Between 10 and 25% of the remaining breeding grounds/occupied habitat likely to be destroyed in less than 10 years
1 Less than 10% of the remaining breeding grounds/occupied habitat likely to be destroyed in the next 10 years

C. PREDATOR/HARVEST IMPACT:

5 Predation/harvest having severe impact on the survival of the taxon
4 Predation/harvest having high impact on the survival of the taxon; or impact unknown but suspected to be high
3 Predation/harvest having moderate impact on the survival of the taxon
2 Light predation/harvest with little impact, or impact unknown but suspected to be slight
1 Predation/harvest insignificant

D. COMPETITION:

5 Competition having severe impact on the survival of the taxon
4 Competition having considerable impact on the survival of the taxon, or impact unknown but suspected to be high
3 Competition having moderate impact on the survival of the taxon
2 Competition having slight impact, or impact unknown but suspected to be slight
1 Competition insignificant

E. OTHER FACTORS AFFECTING SURVIVAL:

5 Other factor(s) exist which are severely affecting the survival of the taxon
4 Other factor(s) exist which are having a considerable impact on the survival of the taxon
3 Other factor(s) exist which are having a moderate impact on the survival of the taxon

2 Other factor(s) exist which are having a slight impact on the survival of the taxon
1 No other factors known

VULNERABILITY

A. HABITAT AND/OR DIET SPECIFICITY:
- 5 Displays extreme habitat and/or diet specificity
- 4 Displays high habitat and/or diet specificity
- 3 Displays moderate habitat and/or diet specificity
- 2 Displays slight habitat and/or diet specificity
- 1 Displays characteristics of a generalist

B. REPRODUCTIVE AND/OR BEHAVIORAL SPECIALISATION:
- 5 Displays reproductive and/or behavioral specialisations which severely limit the recovery ability of the taxon
- 4 Displays reproductive and/or behavioral specialisations which has a high impact on the recovery ability of the taxon
- 3 Displays reproductive and/or behavioral specialisations which have a moderate impact on the recovery ability of the taxon
- 2 Displays reproductive and/or behavioral specialisations which only limit the recovery ability of the taxon
- 1 Displays no reproductive and/or behavioral specialisations which severely limit the recovery ability of the taxon

C. CULTIVATION/CAPTIVE BREEDING:
- 5 Not known to be in captivity/cultivation or germ plasm bank, and/or breeding in captivity/propagation unsuccessfully
- 4 Rarely in captivity/cultivation (not in germ plasm bank), and/or breeding in captivity/propagation not well documented or often unsuccessful and many require highly specialised techniques
- 3 Occasional to frequent in captivity/cultivation, and/or breeding success in captivity/propagation variable. Includes taxa which, while easy to propagate asexually, are difficult to propagate sexually
- 2 Occasional to frequent in captivity/cultivation, and/or breeding in captivity/propagation occurs regularly
- 1 Widely bred/grown in documented collections

VALUES

A. MAORI CULTURAL VALUES:
- 4 Extremely important for one or more iwi
- 3 Moderate-high importance for one or more iwi
- 2 Low-moderate importance for one or more iwi
- 1 Minor significance

B. PAKEHA CULTURAL VALUES:
- 4 Regarded as important by virtually all people

3	Regarded as important by the majority of people	1	Regarded as important by a few people
2	Regarded as important by a moderate number of people		