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# Land indicators for national environmental monitoring – Part 6:

Prioritisation of land monitoring parameters and indicators.

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**Signposts for sustainability**

# LAND INDICATORS FOR NATIONAL ENVIRONMENTAL MONITORING - PART 6:

# PRIORITISATION OF LAND MONITORING PARAMETERS AND INDICATORS

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## CONTEXT AND TERMS OF REFERENCE

This report is one of eight produced as part of a consultancy for the Ministry for the Environment. The consultancy consists of a review and policy analysis of current land monitoring for national environmental indicators and a prioritisation of land monitoring parameters and indicators which provides recommendations for a preliminary core set of land indicators. The consultancy is funded by the 'Green Package' National Environment Indicator Programme.

The terms of reference for this report (Part 6) are:
"Prioritise the monitoring and indicators evaluated in Stage 1, Tasks 1 to 5 into high, medium and low, and present a report recommending the priority indicators pertinent to the development of a preliminary core set of national environmental indicators for land."

"This task should include: (1) the identification of the priority indicators that can be implemented now and those required over the medium and longer term; (2) the prioritisation of the research relationships and the information requirements related to the priority indicators; and (3) an overview of information management systems for land monitoring."

## INTRODUCTION

In the NEIP Land report, Williams and Mulcock (1996) propose that 'intactness' and 'soil health' are composite indicators for land environment monitoring. The concept of intactness expresses whether soils are staying in place or not, and what pressures may be contributing to soil movement. 'State' intactness indicators include soil slip erosion and sediment load in rivers. 'Pressure' indicators are surrogates in the form of the risk of soil loss, where an indicator of 'land use relative to its capability for use' is a pressure indicator of intactness. Soil health indicators need to be a mix of simple indicators (such as acidity) and more complex indices derived from modelling and calculations of nutrient budgets.

## CONSOLIDATED SET OF INDICATORS FOR ENVIRONMENTAL MONITORING

After considering the indicators from the Taranaki monitoring approach (Stephens 1997), from the proposed Otago monitoring method (Hewitt 1997), and from the NEIP Land report (Williams and Mulcock 1996), and after comparing these to the criteria for indicator selection (Hewitt and Stephens 1997a, 1997b; Cleaver 1997), we recommend a consolidated set of 15 land indicators. A large proportion of Regional Councils and Unitary Authorities are already using, or proposing to use, the consolidated set of indicators, suggesting that the indicator set will eventually achieve widespread acceptance and use. The recommended land indicators are discussed below and are shown in Table 1. Of our recommended land indicators the following were not part of Williams and Mulcock's recommended set of indicators:soil physical properties, water and surface erosion, native grassland condition, heavy metal concentration, fertilizer usage, pesticide and herbicide use and effluent disposal.

### Soil Intactness Indicators

"Land use" is an important pressure indicator. As a status indicator it will be used in particular to track the intensification of land use. A general, nationally applicable land use classification is needed that is measurable and related to more detailed regional classifications. It should also include conservation and urban land uses.

"Land use in relation to capability" indicates risk of adverse environmental impact of land use and has been successfully used in Taranaki. Its interpretation requires knowledge of the risk of specific land uses on land types, and it may also indicate the response of land use to policy.

"Land cover" indicates pressure and status. In many instances "land use" may be inferred from "land cover", for example, exotic forestry and residential.

"Extent and frequency of soil slip erosion" is recommended as soil slip is main type of erosion that occurs in hill country (Hewitt and Stephens 1977a). Soil slip erosion is the most easily monitored erosion type and is highly relevant to intactness in the North Island. "Extent and frequency of soil slipping" is also an important state indicator more generally because at least 26 per cent of New Zealand is predisposed to soil slipping (Eyles 1983). The extent and frequency of slipping can be readily quantified with information derived from aerial photography. When slipping occurs, there are a number of environmental impacts: degradation in soil fertility, depressed levels of pasture production, off-site sedimentation and water quality degradation, and reduced net financial returns. The soil slip indicator includes earth slip erosion types.

"Extent and frequency of water and surface erosion" is proposed because about 39 per cent of New Zealand is affected by water and surface erosion types, including wind and sheet erosion (Eyles ibid.). Methods to measure water and surface erosion types are not well established because of the subtle nature of soil movement from these erosion types. However, the caesium-137 technique (Basher et al. 1995) has been applied in New Zealand and should be developed and tested as an operational indicator for flat and rolling land.

**Soil health indicators**

"Nutrient status for New Zealand as a whole and land uses within each ecosystem/land system" may be derived from a nutrient balance calculated from knowledge of gains and losses to the soil-plant-animal system (White 1992) within agro-ecosystems. These gains and losses can then be aggregated to a national level. This indicator is complex and relies on many sources of data and on many assumptions. It has the potential of identifying undesirable losses of major nutrients from primary production ecosystems; however, nutrient loss due to animal losses in unproductive areas, and losses through fixation, immobilisation, leaching or gas evolution, are difficult to validate on a national scale (White 1992). Much development will be needed before this indicator can be used with confidence. Progress has been made on research relating to nutrient balances at the farm scale (OVERSEER model, I. Boddy, AgResearch pers. comm), and a national indicator can possibly be developed by aggregation from a sample of farms. The OVERSEER model is currently valid for pastoral farming, and planned expansion will include horticulture, cropping and production forestry.

"Acidity relative to land use" is a measure of the soil's ability to be productive. It can, however, be manipulated with the addition of lime which is commonly used in most intensive agricultural and horticultural land uses. “Soil acidity” is applicable to parts of New Zealand where the economics of liming are doubtful.

Williams and Mulcock’s (1996) statement regarding “Organic carbon/Total carbon” is unclear. Because New Zealand soils do not normally have non-organic sources of carbon in topsoils, New Zealand researchers use total carbon confidently as a measure of organic carbon. Therefore we believe that the indicator should be named “Organic carbon”. Organic carbon is relevant to the chemical, physical and biological functioning of the soil. It will provide a good measure of the quantity of soil organic matter in cropped soils and, more generally, in soils in regions with a mean annual rainfalls of less than 1000 mm. In all regions, organic carbon will contribute to calculations of the national carbon budget. This budget must meet national greenhouse gasses reporting (which New Zealand is committed to under the Framework Convention on Climate Change). Williams and Mulcock may have understood their indicator as the ratio of “microbial biomass carbon to total carbon”. If this is the case, their indicator “Organic carbon/Total carbon” indicates whether the soil biological system is degrading or recovering. This indicator promises to be an efficient indicator of soil organic matter quality applicable to all ecosystems, but it requires further research and development.

“Pesticide and herbicide concentration”and “heavy metals concentration”are important composite pollution indicators. In order to establish these indicators, key chemicals and elements need to be chosen and suitable sampling strategies developed. National baselines have been established for organochlorines by the Ministry of Environment, and the Ministry’s strategy may be applicable to other chemicals and elements.

“Soil compaction” can be based on a simple measurement and provides a measure of soil structure status. Compaction, or loss of soil structure, is caused by animal treading, over-cultivation or loss of soil organic matter in droughty soils. Pressure on soil structure may be inferred from land use in relation to capability, but a status indicator is also needed.

“Native grassland condition” has been included in the consolidated set of indicators because of its application in the tussock grasslands and, in particular, its use by the Otago Regional Council. This indicator is used to infer the sustainable use of tussock grasslands for grazing, and could possibly be incorporated into the land cover indicator (Gibson and Bosch 1996).

“Fertilizer use”, “pesticide and herbicide use” and “effluent disposal” were included because of the intention to use them in Otago and because of their general policy relevance. They are important pressure indicators that will identify the risks of heavy metal, pesticide and herbicide pollution. “Effluent disposal” must include the type, location and quantities of effluent. It will target soils possibly at risk from heavy metal pollution and sources of water pollution. “Heavy metal concentration” and “pesticide and herbicide concentration” are status indicators which complement their associated pressure indicators.

## PRIORITISATION OF INDICATORS

Comparison of the consolidated list of indicators from Williams and Mulcock (1996) and the

Taranaki and Otago approaches in the fourth part of this series of reports (Hewitt and Stephens 1997b) showed that most indicators in our consolidated set rate highly against the indicator selection criteria (see Table 1). Consequently, none were rated as of low priority. This was not surprising because there had been a fair degree of indicator scrutiny and selection prior to the rating exercise. Many of them show potential but will not be of use in the short term.

High priority indicators are those rated five and above when compared to the selection criteria and are also ticked under "fitness for use now" (Hewitt and Stephens 1997b). The high priority indicators are: extent and location of soil slip, land use, land cover, land use to land capability, soil acidity, organic carbon, soil compaction, heavy metal concentration, pesticide and herbicide concentration, fertilizer use, pesticide and herbicide use, and effluent disposal.

These indicators have been divided into two groups. The first group comprises risk (or pressure) indicators that could be used nationally to identify land at risk. The second group consists of "toolkit" (or state) indicators targeted primarily at the identified areas of risk. The latter are also used to measure status across environmental gradients to validate the risk analysis and provide a balanced picture of high and low risk areas. The high priority risk indicators are: land use, land cover, land use to land capability, fertilizer use, pesticide and herbicide use, and effluent disposal. High priority "toolkit" indicators are: extent and frequency of soil slip erosion, soil acidity, organic carbon, soil compaction, heavy metal concentration, and pesticide and herbicide concentration.

The remaining three indicators are rated as moderate: the extent and frequency of water and surface erosion, native grassland condition and soil nutrient balance.

## RESEARCH REQUIREMENTS

General research requirements for indicator development are listed in the fifth part of this series of reports.

Methods are available for measuring the high priority indicators, though several of them require operational research aimed at developing appropriate sampling strategies and at interpreting the results. Basher and Fitzgerald (1993) discuss the design of sampling networks.

Developmental research is required for the remaining indicators:
The "extent and frequency of water and surface erosion" indicator consists of two components: gullying and surface erosion. More research with remote sensing is needed to record gully erosion consistently. If the caesium-137 technique proves successful, surface erosion may be added to the list of indicators in due course. The caesium-137 technique has been successfully applied on New Zealand's flat and rolling land (Basher et al. 1996). However, methods for estimating caesium-137 input values and sampling strategies need to be established before the technique can be fully tested.
The " native grassland condition" indicator based on vegetation condition models (Gibson et al. 1995) has been tested in Otago and Canterbury. Designed for on-farm condition assessment and adaptive management, the method needs developing further as an operational tool for regional application. The broad vegetation condition classes derived from vegetation condition models

could be included in the land cover indicator.

Before the "soil nutrient balance" indicator can be developed, the OVERSEER model needs to be validated. This model is currently applied to pastoral land use and needs extension to include horticulture, cropping and production forestry.

## DATA ISSUES FOR THE NATIONAL ENVIRONMENTAL INDICATOR PROGRAMME

The spatial framework for the NEIP needs to be nationally consistent, hierarchial to accommodate different levels of detail, and constructed or derived from existing databases (for example, NZLRI, NSD, Statistics New Zealand databases) or from spatial information derived from other projects (for example, MAF Quality Management's AGRIBASE project, the LCDB mapping programme, the MfE's Indigenous Forest & Soil Carbon project and Landcare Research's Ecosystem Depiction programme).

Given that existing datasets probably already exist for the construction of the land system/ecosystem spatial framework, a significant aspect of creating a national monitoring system will be the development of standards and protocols to ensure that the environmental indicator data collected are of acceptable and uniform quality. To enable the production of valid state of the environment reports, the following issues need to be resolved (Newsome and Stephens 1995): data quality and management standards; data transfer protocols; sampling and analysis protocols (which could be different for each indicator); intellectual property and data ownership; responsibility for costs; rules of exchange; data access; archiving and security of data; the valid translation of spatial data (layer and indicator trends) into information via defensible interpretation and data aggregation; and central versus distributed network structure of the information system.

**Table 1. Consolidated set of indicators, fitness for immediate use**

| Indicators | Fitness for use now | Number of criteria met (out of 7) | Priority |
|---|---|---|---|
| **Intactness - state** | | | |
| Extent & frequency of soil slip erosion | ✓ | 6 | High |
| Extent & frequency of water and surface erosion | x | 3 | Moderate |
| **Intactness - pressure** | | | |
| Land use | ✓ | 6 | High |
| Land cover | ✓ | 6 | High |
| Native grassland condition | x | 5 | Moderate |
| Land use to land capability | ✓ | 5 | High |
| **Soil health - state** | | | |
| Soil acidity | ✓ | 6 | High |
| Organic carbon | ✓ | 6 | High |
| Soil compaction | ✓ | 7 | High |
| Heavy metal concentration | ✓ | 5 | High |
| Pesticide & herbicide concentration | ✓ | 6 | High |
| Soil nutrient balance | x | 2 | Moderate |
| **Soil health - pressure** | | | |
| Fertiliser use | ✓ | 7 | High |
| Pesticide & herbicide use | ✓ | 7 | High |
| Effluent disposal | ✓ | 7 | High |

Where
✓ indicates yes
x indicates no

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