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**Land indicators for  
national environmental  
monitoring – Part 2:**

Proposed monitoring for sustainable  
land in Otago.

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**Signposts for sustainability**

**LAND INDICATORS FOR NATIONAL ENVIRONMENTAL  
MONITORING - PART 2:**

**PROPOSED MONITORING FOR SUSTAINABLE LAND IN OTAGO**

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## EXECUTIVE SUMMARY

The Otago region is very diverse in terms of land use intensity, climate, landscapes, soils and vegetation types. The proposed Otago Regional Council monitoring approach stratifies this diversity into land management units which are combinations of land use and land type, and directs its monitoring effort at those combinations most at risk.

The monitoring involves the following categories of information:

- \* land use types  
e.g. semi-intensive mixed cropping land;
- \* land types  
based on combinations of soil, climate and landform, e.g. seasonally dry coastal downlands;
- \* land management units  
combinations of land use types and land types, e.g. semi-intensive mixed cropping on seasonally dry coastal downlands; and
- \* land management functions  
management activities that have an impact, e.g. farm stocking rate, fertilizer application, and rotary cultivation.

The monitored parameters are land management functions. The indicators will be simple measures of the land management functions. For example, 'cows per hectare' will represent a measure of stocking rate.

Land management units at risk will be identified by comparing the land management functions with the soil's capability to withstand impacts. Land management functions likely to cause significant risk will be selected as key indicators for the specified land management units. The indicators will be interpreted and thresholds recognised by examining the soil quality impacts of the land management functions on specific land types. Immediate progress in risk assessment and interpretation of indicators can be made by relying on expert knowledge, but soil quality investigations will also be necessary, to fill knowledge gaps and to establish a defensible monitoring system.

The indicators are essentially soil intactness and soil health pressure indicators which identify land management units at risk. The success of regional policies will be judged according to their ability to reduce relevant risks. Corresponding changes in soil intactness and soil health status will be monitored by direct measurements taken from a number of benchmark sites.

The monitoring system has not been implemented yet. A pilot exercise is planned in the Clutha District, and clarification of research and information requirements, including the feasibility and magnitude of the task, will be one outcome of this project. However, many requirements, can be anticipated, and these constitute part of the pilot study.

There are many connections between the indicators proposed for the Otago system and the simple indicators suggested by Williams and Mulcock (1996) as components of the intactness and soil health composite indicators. It is possible, therefore, that the Otago approach will fulfil Williams and Mulcock's monitoring system requirements.

The proposed Otago system addresses the intactness and soil health composite indicators, but the ecological integrity composite indicator is not specifically addressed. However, the land management unit basis for monitoring, would provide a suitable foundation for monitoring many of the suggested simple indicator components of ecological intactness.

Consequently, if the proposed monitoring system is successful in the Otago region, then the approach should be applicable to all New Zealand regions.

### Part 2. Proposed Otago Monitoring System

## 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 2) are:

Review the proposed Otago Regional Council approach to monitoring sustainable land use which considered but rejected soil quality indicators in favour of land use as an indicator of sustainability:

- To define what is being monitored (the parameters);
- To identify the indicators that are being used to measure sustainability;
- To identify the research relationships and information requirements underpinning the monitoring and indicators;
- To identify the connections and gaps between the proposed Otago monitoring approach and those indicators recommended in the NEIP Land report for 'intactness' and 'soil health';
- Given that the proposed Otago monitoring approach may fit with recommendations for 'intactness', identify the steps that would be required (over time) to add other parameters to the monitoring approach such as those recommended for 'soil health' (eg nutrient balance etc), and ecological functionality; and
- To establish how applicable the proposed Otago monitoring approach would be across New Zealand's regions in terms of monitoring sustainable land use.

## LAND MANAGEMENT OR SOIL QUALITY INDICATORS

In a first attempt to develop indicators for monitoring soil health in the Otago region (Hewitt et al. 1995), a minimum data set of soil quality indicators was chosen. This was similar to minimum data sets proposed by others, notably Doran *et al.* 1994. It was recognised that for each unique combination of land use type, soil type and landform in the region, the list of soil quality indicators in the minimum data set could be reduced to a smaller set of key indicators. These key indicators were chosen for each land use/soil type/landform combination by considering the degradation processes likely to be occurring, and the inherent resistance and resilience of the soils to these processes. The scheme developed was complex. The soil quality indicators, while useful for describing the status of soil quality at the farm scale, were not yet fully developed, and did not fulfil the requirements (ease of measurement, cost effectiveness and accessibility) necessary for regional monitoring.

Because of these limitations, Greenwood (1996) proposed using land management classes and targeting land areas at risk from land degradation as a means of easing the monitoring effort. Indicators based on land management activities would serve as soil quality pressure indicators and would be useful indicators in their own right.

## THE PROPOSED MONITORING

Greenwood (1996) proposed that, "land management indicators can also be used to monitor soil quality

and therefore the Regional Policy Statements relating to water and land.” The indicators would be “land management functions” (e.g. farm stocking rate, grazing intensity and fertilizer applications) recognised within defined farm systems (e.g. dairy farming) (see figure 1 in Greenwood 1996). The land management function indicators would be further defined by recognising levels of risk. For example, farm stocking rate would be expressed as milking cows per hectare, and classes of stocking rates would be rated according to their degradation risk (see table 1).

**Table 1: Interpretation of the “farm stocking rate” land management function indicator (from Greenwood 1996), on a specified type of land.**

<b>Farm stocking rate</b> (milking cows per hectare)	<b>Classification of indicator</b>
<1	rejuvenative
1-2	neutral
2-3	slightly degrading
>3	heavily degrading

In this table, two cows per hectare is identified as the threshold stocking rate for the specified type of land. Indicator thresholds would vary between land types, depending on their sensitivity to the impact of the land management function. Land types would be defined mainly by soil type, climate, and landform.

A significant aspect of this scheme is its relevance to pressures on water as well as on land.

Greenwood (1997) proposed a pilot study to test implementation of the scheme. This involves defining four categories of information:

**Land use type**

for example, high country fine wool sheep, downland fattening sheep, or intensive coastal arable.

**Land types**

based primarily on a combination of soil, climate and landform, but also including other factors such as altitude and depth to aquifer - for example, shallow recent soils in semiarid climate on flat lowlands.

**Land management units**

defined by each unique combination of land use type and land type.

**Land management functions**

for each land management unit, land management activities that will influence soil quality will be identified and ordered according to their perceived effect on soil quality. The high impact land management activities will become key land management function indicators. For example, for downland semi-intensive mixed cropping land, the land management functions include rotary cultivation (high impact and therefore high priority), ploughing (low impact and therefore low priority) and spring tine cultivation (low impact and therefore low priority). A land management function that has a high monitoring priority in one soil type may be of low priority in another soil type.

A preliminary list of land use types, land types and land management functions is appended.

Monitoring may be applied at regional, district and farm scales by defining three respective scales of monitoring units:

- Primary monitoring based on land use type only.
- Secondary monitoring based on a combination of land use type and land type, i.e. land management units.
- Tertiary monitoring with recognition of management functions within land management units.

*In essence the Otago approach aims to classify all its land area into land management units and to direct the monitoring effort at land management units that are at risk. The monitoring will be carried out in a land management unit framework that will delineate areas of similar kind and severity of risk.*

## **RESEARCH AND INFORMATION REQUIREMENTS UNDERPINNING THE PROPOSED MONITORING AND INDICATORS.**

The monitoring system has not been implemented yet. A pilot exercise is planned in the Clutha District, and clarification of research and information requirements will be one outcome of this work. However, many requirements can be anticipated and constitute part of the anticipated pilot study:

### 1. Classification of land use types

For the Otago region this is relatively easily achieved.

### 2. Delineation of land use types

AGRIBASE seems promising and is to be investigated.

### 3. Classification of soil/climate/landform combinations

The NZLRI will be used at regional and district scales, and Regional Council farm plans may be used at a farm level (not digitised), where they exist. Course climate strata will be recognised and mapped from existing regional databases.

### 4. Definition of land management functions for management units

A good first approximation of key land management functions will be made from expert knowledge. Knowledge gaps will be identified as a guide for research (see Lynn et al.).

## 5. Supporting soil quality research

Surrogate variables can be used for monitoring when their relationships to the target variables are well known. The choice of land management indicators, and their interpretation, requires an understanding of the soil quality response to land management effects. The relationships between variables may be determined at carefully chosen benchmark sites. Some immediate progress may be made with expert knowledge, but a research effort will be necessary to establish indicators that are scientifically and legally defensible.

Much relevant research has been done in the Otago region. Harris (1997) has made an inventory of known research relevant to land resource management in the Waitaki and Clutha Districts.

### **CONNECTIONS BETWEEN AND GAPS IN THE PROPOSED OTAGO MONITORING APPROACH AND INDICATORS FOR INTACTNESS AND SOIL HEALTH RECOMMENDED IN THE “LAND” REPORT.**

There are many connections between the indicators proposed for the Otago system and the simple indicators suggested by Williams and Mulcock (1996) as components of the intactness and soil health composite indicators. Ways to increase the connections are suggested below. One important connection is the land system/ecosystem approach.

In Tables 2 and 3 the capability of the Otago system is compared with the indicators proposed by Williams and Mulcock (Tables 12, 13 and 14, pages 75 to 80, 1996 ).

#### **Intactness**

**Table 2: Comparison of proposed Otago monitoring system indicators with Williams and Mulcock’s intactness indicators**

Pressure indicators

<b>Williams and Mulcock</b>	<b>Proposed Otago monitoring system</b>
Land use relative to land capability	Possible if each land unit were rated for erosion susceptibility.
Land cover relative to use	Possible if land cover was mapped.
Net financial returns after all input servicing	No mention is made of financial measures, but use of yields and financial returns is feasible (I. Brown pers. comm.).

Status indicators

<b>Williams and Mulcock</b>	<b>Proposed Otago monitoring system</b>
Extent and frequency of slipping	Monitored primarily in areas where land management functions indicated significant risk. Note that wind erosion is significant in much of Otago.
Site specific soil movements	Monitored primarily in areas where land management functions indicated significant risk.

The capability exists to fill the erosion susceptibility and land cover information gaps.

**Soil health**

**Table 3: Comparison of proposed Otago monitoring system indicators with soil health indicators of Williams and Mulcock**

Pressure indicators

<b>Williams and Mulcock</b>	<b>Proposed Otago monitoring system</b>
Intensification of land use	Easily derived from land use monitoring.
Nett financial returns after all input servicing	No mention is made of financial measures, but use of yields and financial returns is feasible (I. Brown pers. comm.).
Current pesticide/herbicide use relative to persistence/toxicity characteristics	A similar measure is proposed.
Land effluent disposal quantities relative to soil type	'Dairy shed effluent system' proposed. Possibly feasible to monitor quantities as well.

## Status indicators

<b>Williams and Mulcock</b>	<b>Proposed Otago monitoring system</b>
Nutrient status for NZ as a whole	Regional nutrient status is not currently proposed, but trialing of the OUTLOOK farm nutrient balance model is likely.
Nutrient status relative to use by land system /ecosystem	Monitored primarily in areas where land management functions indicated significant risk.
pH acidity relative to use	Monitored primarily in areas where land management functions indicated significant risk.
Organic carbon/total carbon	Monitored primarily in areas where land management functions indicated significant risk.
Pesticide and heavy metal contamination (DDT/cadmium)	Monitored primarily in areas where land management functions indicated significant risk.

## DEVELOPING THE OTAGO MONITORING APPROACH

The proposed Otago monitoring system partially addresses the intactness and soil health composite indicators with connections and gaps shown in tables 2 and 3. The ecological integrity composite indicator is not addressed. The steps listed below are suggested for the development of the Otago indicators to better accommodate the intactness and soil health composite indicators and to address the ecological integrity composite indicator.

Current plans are focused on the intensively used coastal lands with a pilot study planned in the Clutha District. Further pilot studies are needed to test applicability of the system to the tussock grasslands and to conservation native forest lands.

### **Development to accommodate the intactness composite indicator.**

1. Rating of erosion susceptibility of all land units - a one-off exercise.
2. Land cover monitoring by remote sensing. The recognition of relevant vegetation classes in the tussock grasslands may be a challenge for satellite remote sensing.
3. Development of suitable financial measures.

### **Development to accommodate the soil health composite indicator.**

1. Inference of dairy shed effluent quantities from cow numbers and disposal management.
2. Development of suitable financial measures.
3. Determination of the relationship of soil quality status (nutrient status, pH, organic carbon and pesticides/heavy metals) to secondary monitoring units and land management functions.

## **Development to accommodate the ecological integrity composite indicator.**

The Otago proposal is focused on land management indicators which may be used to infer soil intactness and soil health indicators. Some data relevant to ecological integrity could be derived from the analysis of land use classes and their spatial pattern.

*Green fragmentation index.* This is not yet well defined, but Williams and Mulcock (1996) suggest that it should be based on tree/shrub cover with spatial analysis of tree/shrub patches to determine their interconnectedness, relation to water ways, density in urban areas, use as farm shelter and value as wildlife corridors. These criteria of Williams and Mulcock suggest that the following information elements are needed:

1. tree/shrub delineation,
2. vegetation classes,
3. size and shape analysis,
4. waterways, and
5. land use.

The Otago monitoring system will only take the 5th element (land use) into account.

Development of the green fragmentation index will require addition of the other elements. Tree/shrub delineation can be remotely sensed. It is not certain whether vegetation classes will be required, but they may be needed to infer the value of wildlife corridors. Broad vegetation classes could also be remotely sensed. The capability exists to analyse size and shape of land units and relate patches to waterways and land use classes. Data on waterways would only need to be collected once.

*Ecological footprint.* This indicator might only be applied at the national level. However, estimating the national ecological footprint will require the collection of information from regions. The ecological analysis by Bicknell et al. (1996) required the following information:

1. detailed sector economic transaction data,
2. import data,
3. population statistics, and
4. areas under broad land use categories , including areas under roads and commercial and residential buildings.

The Otago monitoring system will only collect the 4th element (land use).

The land management units of the Otago monitoring system would provide a similar basis for most of the other indicators contributing to the composite ecological integrity indicator.-Additional information of climate, population/households and tenure subdivision would also be needed. The land use categorisation proposed by Otago needs to be more comprehensive than currently envisaged. The categories need to include landfills, urban buildings, roads and individual land use unit sizes.

## **Communicating the good news**

The proposed Otago monitoring system is aimed at confining the monitoring effort to those areas of land that warrant most attention. This attention to problem areas will meet the Regional Council statutory responsibilities, but national environmental reporting agencies also need to know the good news.

## **Compatibility with ISO 14000 standards.**

Arising out of community initiatives by the Otago Regional Council, the land care group known as the “North Otago Sustainable Land Management Group” (NOSLAM) has embarked on developing an environmental planning and monitoring system to meet the requirements of the ISO 14001 standard. The objectives of this monitoring are similar to the objectives of the proposed Regional Council monitoring system. Regional and national monitoring systems should, in the interests of efficiency, be compatible with on-farm ISO 14001 monitoring because such market driven standards may well set the pace in indicator development.

## **APPLICABILITY OF THE OTAGO APPROACH TO NEW ZEALAND REGIONS**

The Otago region is very diverse in terms of land use intensity, climate, landscapes, soils and vegetation types. If the proposed monitoring system successfully meets policy requirements in Otago, then it should be successful in all NZ regions. The research and information requirements underpinning the Otago monitoring and indicators are applicable to all regions.

## **REFERENCES**

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- Harris, M. (1997) 1997. Summary of known reports and research related to land resource management in Otago - Waitaki and Clutha Districts. Otago Regional Council Report.
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## **APPENDIX. A preliminary list of land use types, land types and land management functions for the Otago Region (I. Brown pers. comm.)**

## 1. Land Use Types

<b>Sheep farms</b>	Fine wool Breeding ewes/store lambs Breeding ewes/prime lambs Trading store sheep and fattening Stud operations (sale of rams etc) Mixed with diary grazing Mixed with breeding cows/store stock Mixed with breeding cows/fattening Mixed with cattle trading and fattening operation Mixed with cropping Mixed with share cropping Mixed with supplementary feed sales Mixed with greenfeed production Mixed with deer Mixed with forestry
<b>Dairying</b>	Milking platform Town supply Factory Self contained (breed and rear replacement) Cows wintered off
<b>Deer</b>	Deer only Mixed with other operations Fattening Velveting Breeding and store sale
<b>Cropping</b>	Intensive cereal cropping Mixed cropping Small seed cropping Mixed with sheep and other enterprises
<b>Market gardening</b>	Veges (surface crops) e.g. lettuces, cabbages etc Root crops e.g. potatoes, carrots Flowers Herbs Mixed with livestock Ready lawn
<b>Cattle</b>	Breeding and fattening Fattening Mixed with sheep
<b>Horticulture</b>	Stone and Pip fruit Berry fruit Grapes Nuts
<b>Forestry</b>	Exotic
<b>Nurseries</b>	
<b>Conservation</b>	Indigenous tall tussock grasslands Indigenous mixed tussock grasslands Indigenous short tussock grasslands

Herb field etc  
 Indigenous forest

## 2. Soil/climate/landform combinations

Soil	Climate	Landform
Pallic soils (dry loessial)		<input type="checkbox"/> flat lowland <input type="checkbox"/> rolling downland
High fertility volcanic associated with limestone		
Fine alluvial		<input type="checkbox"/> flat lowland
Stoney alluvial		<input type="checkbox"/> flat lowland
HC Brown Allophanic and Acid soils		<input type="checkbox"/> steep mid altitude <input type="checkbox"/> high altitude
Lower inland Brown, (Orthic, Mafic Firm) soils		<input type="checkbox"/> rolling downlands <input type="checkbox"/> steep mid altitude
Inland Pallic soils		<input type="checkbox"/> flat lowlands
Semiarid soils		<input type="checkbox"/> rolling downlands <input type="checkbox"/> flat lowlands <input type="checkbox"/> rolling downlands <input type="checkbox"/> steep mid altitude
Pallic soils (wet loessial)		<input type="checkbox"/> flat lowland <input type="checkbox"/> rolling downland
Coastal low brown soils		<input type="checkbox"/> flat lowland <input type="checkbox"/> rolling downland
Podzol soils		
Low fertility volcanics		rolling downlands steep mid altitude
Gley soils		flat lowland rolling downlands
Coastal sand soils		
Organic soil		
Other (includes rock etc)		

## 3. Management Function

Burning & extended spell	Fertiliser application	Stubble burning
Burning & limited spell	Fertilizer-concentrated	Stubble mulching
Burning + fertiliser	Grazing & fertiliser	Sub soiling
Burning + no fertiliser	Grazing & no fertiliser	Tracking
Chemical application	Grazing extensive	Wind rowing
Chemical storage	Grazing mob stocking	
Cultivation fallow	Grazing rotational	
Dead animal disposal	Grazing strip	
Direct drilling	Irrigation border	
Drainage - mole	Irrigation spray	
Drainage - tile	Minimum tillage	
Effluent disposal	Ploughing	
Feed conservation-greenfeed	Rabbit control	
Feed conservation-hay	Rubbish disposal	
Feed conservation-silage	Springtime cultivation	