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Signposts for sustainability

LAND INDICATORS FOR NATIONAL ENVIRONMENTAL MONITORING - PART 1A:

NEW ZEALAND LAND RESOURCE INVENTORY

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EXECUTIVE SUMMARY

The New Zealand Land Resource Inventory (NZLRI) is a nationally significant database of physical land resource information. While originally published in the form of printed maps, the data is now primarily managed in a GIS. Landcare Research is the custodian of the NZLRI, which covers New Zealand in 12 regions. Each region has a separate Land Use Capability (LUC) classification. The first edition NZLRI was mapped at a scale of 1:63360. Second edition, 1:50000 scale NZLRI mapping has been completed for Northland, Wellington, part of Marlborough and part of Waikato and is currently in progress in the Gisborne East Coast region.

The NZLRI comprises two sets of information - an inventory of five physical factors and a LUC assessment. The NZLRI contains mapped areas (or polygons) called 'inventory map units'. The five physical factors (rock, soil, slope, erosion, and vegetative cover) are used to define each multifactor inventory map unit. The inventory (of five physical factors) records land attributes that are important for sustainable land use planning. The inventory is established by reference to pre-existing information, field verification and aerial photograph interpretation. There are approximately 100000 inventory map units delineated in the NZLRI.

Each inventory map unit also has a LUC assessment, established on the basis of the five physical factors, climate, and the effects of past land use. LUC assessments appear in a three-part hierarchy. Each level increases in detail, from LUC class, to LUC subclass, and finally to LUC unit.

The LUC class is the broadest category of the LUC classification system. It expresses the *total degree of limitation* to sustainable use. Eight LUC classes are used in New Zealand, class I representing negligible and class VIII extreme limitation.

The LUC subclass is the second category and expresses the *major kind of limitation*. The NZLRI uses four 'LUC subclass limitations: erosion (e), wetness (w), soil (s), and climate (c). The 'LUC subclass' comprises the LUC class and subclass limitation, and is expressed, for example, as VIe.

The LUC unit is the most detailed category. Each LUC unit is defined by its assemblage of physical attributes: rock, soil, landform, slope, erosion, and climate (although other factors such as vegetative cover, land use and productivity indices are also taken into account). A LUC unit groups inventory map units together which respond similarly to the same management; which are adapted to the same kinds of crops, pasture or forest species; which have about the same potential yield; and which require the same soil conservation and other land management measures. There are over 700 different LUC units in the NZLRI. Each unit is indicated by an Arabic number which follows the subclass limitation symbol (for example, VIe1). Each of the 12 NZLRI regions has a unique set of LUC units. LUC units from the first edition mapping of the North Island have been correlated. In this correlation, LUC units which are essentially the same, but belong to different regions, are grouped together to help users working across regional boundaries.

The key to the NZLRI's usefulness is that it is a spatial database (spatial framework) covering the whole of New Zealand . The NZLRI can be used for primary or secondary interpretations of data. Primary interpretations seek information on one, or a combination of, existing factor(s)recorded in the NZLRI. Users making primary interpretations need only to understand

the principles of the mapping and LUC classification system, limitations of scale, and the significance of the time of data collection for the changeable factors such as vegetation cover and erosion. If these requirements are not recognised, the use of the NZLRI database can be inappropriate.

Secondary interpretations are those where the NZLRI intersects with other databases or where new knowledge is added from other sources to establish useful new interpretations. Although the primary uses of the NZLRI database are limited by the factors recorded, the secondary uses appear boundless.

The NZLRI programme for the first edition mapping was completed between 1973 and 1979. Second edition mapping has been undertaken episodically since that time. Information such as rock, soil, slope, and characteristic erosion associations have not changed significantly and have therefore not become outdated. However, erosion type and extent as well as vegetation cover can change. With respect to these factors the NZLRI does become out-of-date.

In terms of sustainable land use monitoring, the date of vegetation cover information in the NZLRI is vital. It is important to have up-to-date vegetation cover information which indicates land changes and from which land use can be inferred. Cost-effective methods of updating the NZLRI vegetation factor using satellite data have been developed. Similar mapping techniques are being employed to map the Land Cover Database (LCDB). However, the vegetation classes mapped for the LCDB are less specific compared to the NZLRI vegetation cover classification. Satellite data has also been evaluated for land use mapping, and accuracies of up to 90 per cent have been achieved.

Concerns have been voiced about using LUC classifications of the NZLRI to produce physiographic land categories such as 'land systems' for monitoring frameworks because the LUC system of land classification is agriculturally based. Such concerns are unfounded, as land is usually adequately described in physiographic terms.

There will be some LUC units in some regional classifications that do not provide quite enough information to categorise land systems adequately, but in these instances, there would be enough understanding of specific problem areas to make an effective adjustment. Use of the NZLRI, especially at the LUC unit level, for establishing these alternative frameworks regionally or nationally is a practical necessity in order to avoid conducting a completely new kind of land resource survey.

The NZLRI would be a useful nation-wide GIS database for the Ministry for the Environment's National Environmental Indicator Programme, at both regional and national scales. The NZLRI is directly applicable to national environmental monitoring by being able to, contribute to the classification of land type, extrapolate soil properties from the NSD to GIS-produced maps of soil type and specific soil characteristics, assist in the development of a rating for all land types which indicates the propensity to erode, provide a consistent LUC assessement for all land types, and show past vegetation types.

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 1A) are to discuss the New Zealand Land Resource Inventory (NZLRI) data base and what it can/can't do and an explanation of whether or not the NZLRI can be broken down into discrete layers and aggregated in any way for different purposes.

INTRODUCTION

Regional and district planning documents are developed with reference to available physical land resource databases. These databases help to define *areas of potential adverse effects* of land uses or management practices, areas with land-use limitations, and areas of land-use opportunity. The planning documents assist in the development of management guidelines, policies, and rules. The NZLRI is used extensively for these purposes in New Zealand. It is the only database with nationwide coverage at an appropriate and uniform scale (Jessen and Harmsworth 1997).

THE NZLRI

The NZLRI is a national spatial database of physical land resource information. The collection of databases which includes the NZLRI has been awarded 'national significance' status by the Foundation for Research Science and Technology. Landcare Research is the custodian of the NZLRI; the Public Good Science Fund provides funding for this purpose. While originally published as printed maps and still available in that form, NZLRI data is now primarily managed as a GIS database.

The first edition of the NZLRI which provided national coverage was mapped between 1973 and 1979 at a scale of 1:63360. Second edition, 1:50000 scale NZLRI upgrading has been completed for Northland, Wellington, part of Marlborough and part of Waikato, and mapping is currently underway in the Gisborne East Coast NZLRI region.

The NZLRI comprises two sets of information - an inventory of classified data describing five physical factors, and an interpreted LUC assessment. In practice, this core data set is supplemented considerably on the GIS with the addition of derived fields of productivity, parameters, and correlators or generalisations for particular applications.

Five physical factors

The NZLRI presents mapped areas (or polygons) called 'inventory map units' in a series of maps and/or GIS coverages. These inventory map units are delineated using a homogeneous map unit method (Eyles 1977), in which five physical factors - rock, soil, slope, erosion, and vegetation

cover - are mapped simultaneously within the limitations of scale. There are approximately 100000 inventory map units delineated in the NZLRI. Each contains its multifactor inventory of five physical factors and a LUC assessment.

The inventory of five physical factors records land attributes that are important for sustainable land use planning, and is delineated and described by reference to pre-existing information, field verification and aerial photograph interpretation.

A rock type classification has been developed to suit the specific needs of the NZLRI (Lynn and Crippen 1991). This classification groups rocks with similar erosion susceptibilities and characteristics, and concentrates on those rocks which directly influence surface morphology and land use (Eyles 1990).

Where possible, soil information has been obtained from existing soil surveys, and field checks have been used to validate the information. Where soil data has not been available at an appropriate scale, physiographic analysis has been used to re-interpret small scale information to fit the 1:63360 or 1:50000 scale.

Slope is classified into seven classes: A (0-3^{o}), B (4-7^{o}), C (8-15^{o}), D (16-20^{o}), E (21-25^{o}), F (26-35^{o}) and G (greater than 35^{o}). These groupings are based on broad management criteria. At larger mapping scales, the groupings can be further subdivided to include criteria such as aspect, position on slope and exposure.

Thirteen erosion types are recorded in the NZLRI, and the degree of erosion has been ranked in six parts (0-5) (Eyles 1985). For sheet, wind, and scree erosion, the ranking was a visual estimate of the per cent bare ground within each map unit. For fluvial and mass-movement erosion types (for example debris avalanches and soil slips), the degree of present erosion is based on seriousness, taking into account the area affected and the technical difficulty and estimated cost of repair.

For NZLRI vegetation cover mapping, emphasis has been placed on identifying important species and associations rather than on providing a botanical classification (Hunter and Blaschke 1986). Classes are recorded in five broad vegetation cover groups: grassland, cropland, scrubland, forest and miscellaneous.

Land Use Capability assessment

The NZLRI covers New Zealand in 12 regions. Each region has a separate Land Use Capability (LUC) classification. The LUC classifications are described in extended legends that are available along with the printed maps or GIS coverages. Illustrated descriptions of the classifications for seven regions have been produced (the latest include Page 1995, Harmsworth 1996, and Lynn 1996).

A LUC assessment has been made for every inventory map unit in the NZLRI. LUC assessments were based on the ability of the land (assessed in terms of the five physical factors, climate and the effects of past land use) to sustain agricultural production (Page 1995). LUC assessments are made in a three-part hierarchy in ascending level of detail: LUC class, LUC subclass, and LUC

unit. The LUC system used in the NZLRI was adapted from Klingebiel and Montgomery (1961). The system, in its various adaptations, is routinely used in over 50 countries. The NZLRI is described by the Soil Conservation and Rivers Control Council (1969), National Water and Soil Conservation Organisation (1979), and by Fletcher (1987) and Eyles (1992).

- the LUC class is the first and broadest category of the LUC classification system. It expresses the *total degree of limitation* to sustainable use. There are eight LUC classes used in New Zealand, from class I (negligible limitation) to VIII (extreme limitation). Classes were traditionally denoted by Roman numerals, but Arabic numerals are now widely used, as they can be more easily integrated with GIS.

- the LUC subclass is the second category and expresses the *major kind of limitation*. The NZLRI uses four 'LUC subclass limitations': erosion (e), wetness (w), soil (s), and climate (c). The 'LUC subclass' comprises the LUC class and subclass limitation, for example, VIe or 6e. There are only 30 LUC subclasses in New Zealand. Consequently, users need to be aware that land management strategies derived from LUC subclass alone are based on general information.

- the LUC unit is the third and most detailed category. Each LUC unit is defined by its unique assemblage of physical attributes: rock, soil, landform, slope, erosion, and climate (although other factors such as vegetative cover, land use and productivity indices have often been added). A LUC unit (in concept and by application in mapping) groups uniform land types together. Specifically, a LUC unit will group inventory map units which respond similarly to the same management; which are adapted to the same kinds of crops, pasture or forest species; which have about the same potential yield, and which require the same soil conservation and other land management measures. There are over 700 different LUC units in the NZLRI. They are therefore much more – useful for planning documents than the LUC class or subclass. A LUC unit is indicated by an Arabic number placed after the subclass limitation symbol, (for example, VIe1).

  Each of the 12 NZLRI regions has a unique set of LUC units. For example, VIe1 in the Waikato region is specific to that region, and different from VIe1 in the Wellington region. Page (1985) correlated LUC units from the first edition regional classifications of the North Island (i.e., LUC units that are essentially the same, but occur in different regions, are grouped together) to help users working across regional boundaries.

APPROPRIATE AND INAPPROPRIATE USES OF THE NEW ZEALAND LAND RESOURCE INVENTORY

The NZLRI database can be used in two ways:

- for primary interpretations of data, depicting (or analysing) land attributes in a form little different from the database's stored state; and
- for understanding secondary interpretations of data to produce depictions (or analyses) of effectively new information.

Primary interpretations are those that seek information on one, or a combination of, previously recorded factor(s) (Maps 1-4 demonstrate these). No added information is required for primary

enquiries. Commonly, primary uses of the NZLRI database are associated with regional and district-wide planning documents that link land use or management requirements to land classifications (Eyles *et al*. 1993). For example, LUC class, subclass or unit may be required to support a regional policy; or information on one of the inventory factors such as slope may be required to put a regional rule into effect. Users making primary interpretations need to understand the principles of the LUC classification system (for LUC-based enquiries), the limitations of scale, and the significance of the time of data collection to changeable factors such as vegetation cover and erosion. Where these are not recognised by users (Jessen and Harmsworth 1997), the use of the NZLRI database may been seen as inappropriate, and may even be challenged in the Environment Court.

Secondary interpretations are those where the NZLRI intersects with other databases or where new knowledge from other sources is added to establish what is essentially a new interpretation - i.e., where information is added and the NZLRI becomes more useful. There have been numerous examples of these kinds of uses:

- identification of 'high class soils' (Webb *et al.*1996). Ten soil attributes from the National Soils Database and other unpublished soils datasets (two climatic factors and a slope factor) were linked to LUC data from the NZLRI;

- determination of rabbit proneness ratings for New Zealand (Kerr and Ross 1990);

- corridor analysis (TransPower NZ Ltd 1988) for electricity transmission route feasibility;

- definition of broad land categories such as land systems for monitoring programmes (Eyles *et al*. 1993);

- soil carbon studies where the amount of carbon stored in New Zealand soils was assessed and a soil carbon map produced (Tate *et al.* 1993). More recently, a soil map of New Zealand has been produced using IPCC (International Panel on Climate Change) categories (Daly and Wilde 1997);

- compilation of soil maps. The New Zealand Soil Classification (Hewitt 1993) was linked to the NZLRI to produce a new map (e.g. Rijkse and Hewitt 1995).

The key to the effectiveness of the NZLRI is that it is a spatial database (framework) covering the whole of New Zealand.

While the primary use of the NZLRI database is limited by the recorded factors, the secondary uses appear boundless. Nevertheless, the limitations of the NZLRI database (*viz*., those of scale, reliability of the data and interpretations, and the use of a polygon-based GIS - there is some information loss when establishing polygons) need to be recognised to eliminate inappropriate applications.

SCALE ISSUES

While the inventory classifications and the LUC system of land classification are independent of scale, inventory factors and LUC are mapped in the NZLRI at a scale of 1:63360 (first edition)

and 1:50000 (second edition). Inventory map units of the second edition have a minimum size that represents 25ha on the ground. It is implicit in mapping that the information recorded will not adequately describe some parts of the map unit. A rule-of-thumb assumption for mappers and users of the information is that up to 15 per cent of any inventory map unit might be insufficiently described. It is therefore important not to apply NZLRI data at scales larger than the original mapping scale because the inherent non-representative parts of an NZLRI map will be relatively closer in size to the resolution required by a large scale application, and wrongful depiction will assume greater importance. When information is sought for areas that are best represented by larger mapping scales, or for site interpretations (such as for excavation suitability), data is best gathered separately and independently from the NZLRI maps (using the NZLRI maps as a guideline only).

IS THE NEW ZEALAND LAND RESOURCE INVENTORY OUT OF DATE?

The NZLRI programme for the first edition (1:63360 scale) mapping was completed between 1973 and 1979. Second edition (1:50000 scale) mapping has been undertaken episodically from 1979 to the present. LUC assessments (at class and subclass levels in particular) for each inventory map unit are made by interpreting permanent physical factors (rock type, soil, slope, characteristic erosion associations, and climate). Because these factors are relatively constant, the NZLRI is not outdated with respect to these factors. However, erosion type, erosion severity and vegetation cover can change. With respect to these factors the NZLRI does become out-of-date.

Vegetation cover information in the NZLRI

In terms of sustainable land use monitoring, the date of vegetation cover information in the NZLRI is of major significance. Land use can be inferred from vegetative cover. It is therefore important to have up-to-date vegetation cover information to provide an indication of land changes. As second edition mapping has been undertaken on a piece-meal basis, and because of the relatively high cost of traditional NZLRI mapping, researchers have been investigating more cost-effective methods of updating the NZLRI vegetation factor. Dymond *et al*. (1995) demonstrated that the Landsat Thematic Mapper satellite imagery and spatial data integration could be used for quick and cost-effective updating of vegetation cover within existing NZLRI polygons. Using the same type of satellite data, Dymond *et al.* (1996) described how stand-alone vegetation maps could be produced for large regions. Similar mapping techniques using satellite imagery are being employed to map the Land Cover Database (LCDB). However, the number of vegetation classes from satellite imagery is less than the number in the NZLRI vegetation cover classification (see Map 4). Satellite data has also been evaluated for land use (as well as for vegetation) mapping by Wilde *et al*., who demonstrated that land use mapping accuracies of up to 90 per cent could be achieved, provided sequential satellite imagery was available.

CONCERNS ABOUT USING THE LAND USE CAPABILITY CLASSIFICATION

Concerns have been expressed about using LUC from the NZLRI to produce physiographic land categories such as ‘land systems’ for monitoring frameworks, mainly because the LUC system of land classification is agriculturally based. However, it is our view that while the LUC class progression from I to VIII certainly does reflect increasing difficulties for agricultural use, land

is adequately described by the five physical factors in the inventory mapping unit, and in physiographic terms in the most detailed level of the classification system (the LUC unit). When using LUC unit information to construct regional interpretations of larger physiographic units such as land systems, it is necessary to involve people who have a detailed knowledge about the regional LUC classifications and who can readily identify and overcome instances where the LUC unit is unable to describe land in appropriate terms.

Recent concerns about using LUC assessments from the NZLRI worksheets for regional planning were raised in the article "The Dilemma of Mapping For Regional Planning" (Robertson and Williams 1996). Concerns arose following a recent case where the Marlborough District Council sought prosecution for what it believed to be an inappropriate excavation. Judge Treadwell dismissed the case at a pre-hearing conference. Robertson and Williams's suggestion that the case might be seen as seriously challenging the use of LUC for planning is considered an over-reaction by Jessen and Harmsworth (1997). Although Judge Treadwell's Decision (13 June 1996) appears valid in view of the inadequacies of the case presented, we believe that the case does not provide a national precedent for changing the way spatial land resource information is used in regional planning. The case was weak because the LUC system had not been properly understood. Matters of scale had not been appreciated by the informant, and there was uncertainty about the LUC assessment for the land in question.

VALUE OF NZLRI TO A NATIONAL ENVIRONMENTAL INDICATOR PROGRAMME

The NZLRI would be a useful nation-wide GIS database for the Ministry for the Environment's National Environmental Indicator Programme, at both regional and national scales. The NZLRI is directly applicable to national environmental monitoring by being able to:

- contribute to the classification of land type, which will be required when a land/ecosystem classification is developed for New Zealand;
- extrapolate soil properties from the NSD to GIS-produced maps of soil type and specific soil characteristics;
- assist in the development of a rating for all land types which indicates the propensity to erode. Propensity to erode is a fundemental land characteristic when the location and type of land-use risks are being established;
- provide a consistent LUC assessement for all land types. This will be useful when risk of unsuitable use is being determined by use of the pressure indicator land use in relation to its capability for that use; and
- show past vegetation types, so that when used in combination with more up-to-date vegetation databases (for example, the LCDB, or 2nd edition NZLRI) the location and extent of vegetation cover changes (and in many cases, land use changes) can be determined.

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