New Zealand Land Use Database

Envirolink Project LCRX0901

Draft Database Design Report

Landcare Research
Manaaki Whenua

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Envirolink

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Contents

Summary

Project and Client

- The Regional Council Land Monitoring Forum (LMF) and Landcare Research are collaborating on the project, which runs from January 2010 to December 2011
- The project aims to design a national Land Use Database (LUDB) consisting of: a land information engine for collecting, synthesizing, generating, reporting and storing land-use information; a classification to represent land use consistently across multiple scales; and an associated geospatial land-use layer to quantify and analyse land-use trends.

Objectives

- Prepare a development case for the Land Use Database (LUDB) based on gaps and priorities identified from the recent LUDB Gap Analysis and Prioritisation Report (Morgan et al. 2010) and discussions based on a recent presentation given by project team members at the Land Monitoring Forum meeting held in September 2010 in Blenheim
- Develop draft specifications for the LUDB for review by the LMF
- Finalise LUDB specifications in agreement with the LMF following their review.

Development Case

Based on the results of the gap analysis and prioritization report, the following characteristics are necessaryfor the LUDB:

- *Flexibility* – accommodate a range of data input sources, land-use classifications, and associated methodologies
- *Adaptability* – able to evolve and accept new input data, methods, etc., over time
- *Memory* – store all input information, methods, classification schemes and associated metadata to allow regeneration of land-use information to go forward.
- *Repeatable* – a user can generate land-use information on an as-needed basis
- *Authoritative* – holds metadata and other information documenting all processes undertaken to generate land-use information, e.g., steps taken to generate a particular land-use classification are recorded for future reference, as opposed to just storing the classification itself.

LUDB Design Considerations

The conceptual design of the LUDB will be a system consisting of five elements:

1. Transformation Tools and Data Input
2. Atomised Data
3. Land-use Classifier
4. Land-use Layers
5. Data Portal, and/or Public Website.

For this project, a more limited first-generation Land Use Database (LUDB) will be developed given available resources. This creates a number of design considerations for review and selection by the members of the LMF. In the longer term, it is hoped that the LUDB will evolve and grow to accommodate a wider range of input data sources, land-use classifications and classification methodologies, and output land-use geospatial data layers.

There are five key design considerations for the LUDB. Those design considerations are interrelated such that choices made for one consideration may affect or limit the choices made for another consideration.

1. *Available Data Sources*
   What input data sources are available for use in the first generation LUDB?
   Given available resources, this project will restrict input data sets to those that are publically available and nationally consistent. Those include the Land Cover Database, Land Resource Inventory, Land Environments of New Zealand, and Census. In addition LMF members have been asked to identify and nominate 1-3 council-held data sources for possible inclusion in the LUDB. Those data sources must be nationally consistent or made to be so within the timeframe of the project.

2. *Data Transformation Procedures*
   What transformation procedures need to be developed for the available input data sources?
   For each input data source we will develop a procedure to transform input data into a format suitable for the LUDB. Tools developed for national datasets will be standard while tool developed for council datasets will likely require some level of customisation. Because data transformation procedures are dependent on the input data sources, they cannot be defined until those data sources are selected.

3. *LUDB Structure and Delivery Method*
   What is the preferred structure and delivery method of the LUDB?
   LUDB can be delivered as either a Local Tool (i.e. installed at a council) or a Web Tool (i.e. accessible over the internet). Selection of either option will influence the structure of the LUDB, as each relies on somewhat different architectures and technologies. Also each option has its own benefits and drawbacks:

a. Local Tool

    i. Benefits: Fully transparent; council staff can make changes directly

    ii. Drawbacks: Potentially easily "broken;" may require specific infrastructure requirements such as software licences; harder to update; requires space on council systems

b. Web Tool

    i. Benefits: Less likely to be "broken" by a user; more general although some web browsers may not work as well; easier to upgrade/maintain; less or no space required on council systems

    ii. Drawbacks: Less transparentl; initially harder to make changes.

4. National Geospatial Land-Use Layer Specifications
What are the specifications for the geospatial land-use layer that the project will deliver?
The project will deliver a national geospatial land-use data layer. This requires agreement on several options including format (vector, raster), projection (New Zealand Transverse or New Zealand Map Grid), and spatial, temporal, and informational resolution subject to what is feasible given available input data sources. Based on discussions at the recent LMF workshop, LMF members indicated that they need to consult with other staff at their organisations to determine the preferred specifications for the geospatial data layer. There is a possibility that the LUDB may be able to deliver mutliple specifications, but that will require further investigation.

5. *National Land-Use Classification*
What land-use classification is desired?
Development of a preferred nationally consistent, cross-council land-use classification is the subject of a separate concurrent work stream within the project. However, we have included information on six existing land-use classifications in this report for LMF members to reference as they work through that process.

    a. Land Use New Zealand

    b. Creating Futures Land Use

    c. AgriBase

    d. Environment Canterbury Land Use for Water Quality

    e. LINZ Land Use for Rating Valuation

    f. Land Use and Carbon Analysis System (LUCAS).

Next Steps

The report outlines five key considerations for the design of the LUDB that LMF members must consider. The next step are as follows:

1. Report circulated to LMF members for review and consideration along with an accompanying worksheet that helps guide LMF members through the steps needed to address the design considerations

2. LMF members address the design considerations outlined in the report

3. LMF members and project team members discuss the five key design considerations at a workshop in February 2011 and agree a set of preferred alternatives, including a draft national land-use classification

4. Project team members finalise database design and the draft land-use classification based on feedback received and workshop discussions and circulate them to LMF members.

1 Introduction

The New Zealand Land Use Database Project is a 2-year Envirolink Tools project running from January 2010 to December 2011. The Regional Council Land Monitoring Forum and Landcare Research are collaborating on the project, which aims to develop a national Land Use Database (LUDB) consisting of:

- Land Information Engine – for collecting, synthesising, generating, reporting and storing land-use information
- Classification – for consistently representing land use across multiple scales
- Geospatial Land Use Layer – for quantifying and analysing land-use trends.

The LUDB will benefit all regional councils, as well as city and district councils, relevant central government ministries and departments, and other agencies with an interest in better land-use planning in New Zealand. Intially the LUDB will cover the North, South, and Stewart islands and inshore islands. The Chatham Islands and offshore island groups will not be covered. The LUDB will help both regional and city/district councils plan the appropriate allocation and distribution of land uses within their jurisdictions to help deliver multiple beneficial outcomes to their constituent communities. For example, councils could enhance and restore native biodiversity by targeting conservation and pest management efforts or set reserve high-quality lands for agricultural production. They could recommend or require improved land-use management practices to foster sustainable primary production, or they could better accommodate growth by directing future urban land uses to appropriate locations.

More important, better land-use information will help councils and other organisations outline the choices and trade-offs among different land-use configurations and help identify the long-term consequences of different land use change trajectories. For example, a recent study showed that urbanisation disproportionately affects New Zealand's most versatile and productive soils (Rutledge et al. 2010), which could impact negatively on New Zealand's primary production capacity in the long term. Better knowledge of land use and land-use change could help prevent such irreversible losses.

By developing a nationally consistent framework for the collection, analysis, dissemination, and reporting of land-use information, the LUDB will also provide all councils within New Zealand with the ability to monitor and report on the state of land use within their jurisdiction. Similar to databases or tools developed for other purposes, such as the suite of environmental classifications (Land Environments of New Zealand, River Environment Classification, Fresh Water Environments of New Zealand), access to better land-use information will help councils identify and articulate significant resource management issues and formulate plans and policies that promote the sustainable use of natural resources. Because it will include spatially explicit information, the LUDB will aid the explicit delineation of potential costs and benefits of different land-use configuration and foster improved deliberation processes in all council planning and management activities.

This report serves as a discussion document for consideration by members of the Regional Council Land Monitoring Forum Special Interest Group (LMF) to help them decide on key aspects of the LUDB design. First, it addresses gaps and priorities identified in the first phase

of the project (Morgan et al. 2010). Second, it outlines a broad conceptual approach to LUDB design. Third, it presents a list of questions and options for the LMF to consider and decide. The choices made will influence the further development of the LUDB in this project.

2 Background

Robust information on land use is critical for effective policy, planning, and resource management. Yet New Zealand has no enduring, coordinated, and consistent approach to the collection, analysis, curation and reporting of land-use data (Rutledge et al. 2009). Instead, as documented as part of a survey in the first stage of this project (Morgan et al. 2010), land-use information is compiled from a variety of sources collected using different methods and at different scales. Regional Councils reported 27 different sources of land-use information, with the top 5 being (in order of frequency):

- Land Cover Database (LCDB)
- AgriBase
- Remote Sensing (Air or Satellite Photos)
- New Zealand Land Resource Inventory (NZLRI)
- Statistics NZ (Census).

The remaining sources spanned a broad number of information types ranging from direct observation, such as monitoring sites, to derived or re-interpreted information, such as specific land-use classifications created for specific projects (Morgan et al. 2010). For example the land-use classifications created for the Catchment Land Use for Environmental Sustainability (CLUES) and Creating Futures projects are both recompilations of other data sources (Woods et al. 2008; Rutledge et al. in press).

Of the top five land-use data sources, only Agribase and the Statistics NZ provide direct information on land use. That is because both are based on surveys of people using the land. AgriBase is an annual survey of farmers and their land-use practices. Statistics NZ undertakes periodic surveys of the general population (Census) and businesses to compile statistics that yield some information on land use, e.g., dwellings (residential). Land cover and remote sensing provide information on the biophysical characteristics from which land use can be inferred, with varying degrees of confidence. The NZLRI operates similarly by supporting inferences about land use based on underlying land and soil capabilities.

Going forward, land-use information will continue to come from a variety of sources. Many data sources will not have provision of land use as a primary purpose, whereas some sources will specifically collect land-use data. Therefore some data sources will be opportunistic, and their contributory value to informing land use may not be immediately recognised and utilised, e.g., “found data.” Indeed, the variety of sources and application of land-use information is not the issue.

The substantive issue is the lack of a framework for the general uptake, analysis and application of land-use information. As documented previously (Rutledge et al. 2009), several previous attempts to produce an official land-use classification for New Zealand have

failed. Instead there are currently several land-use classifications in operation, each created for various purposes. Those classifications will be discussed in more detail later in this report.

The failure to produce an official classification stems from the complex nature of land use and land-use information (Rutledge et al. 2009). Previous attempts failed because they focused on the land-use *classification*. In two cases, the design process led to the creation of detailed, hierarchical classifications containing over a thousand classes each. The feasibility of the desired classification received comparatively little attention. The various land-use classifications operating today are significantly simpler by comparison, each having only a few dozen classes at most. Furthermore, documentation of the process for generating each of those classifications varies substantially.

Previous research (Rutledge et al. 2009) therefore recommended focusing not on a particular classification but rather on the *process* of land-use characterisation and classification. Rather than attempting to create a monolithic land-use classification, effort should be focused instead on developing an adaptable and flexible process that allows multiple data sources to be combined in different ways to satisfy a variety of land-use information needs. Indeed the existence of multiple land-use classifications in use today reinforces the need for flexibility and adaptability in land- information and application.

Figure 1 provides a conceptual drawing of that idea. Multiple data sources feed into a common database, which can be either centralised or distributed. Stored in the database are processed data, classification specifications, and associated methods and procedures for generating different types of land-use information (e.g., geospatial land-use data).

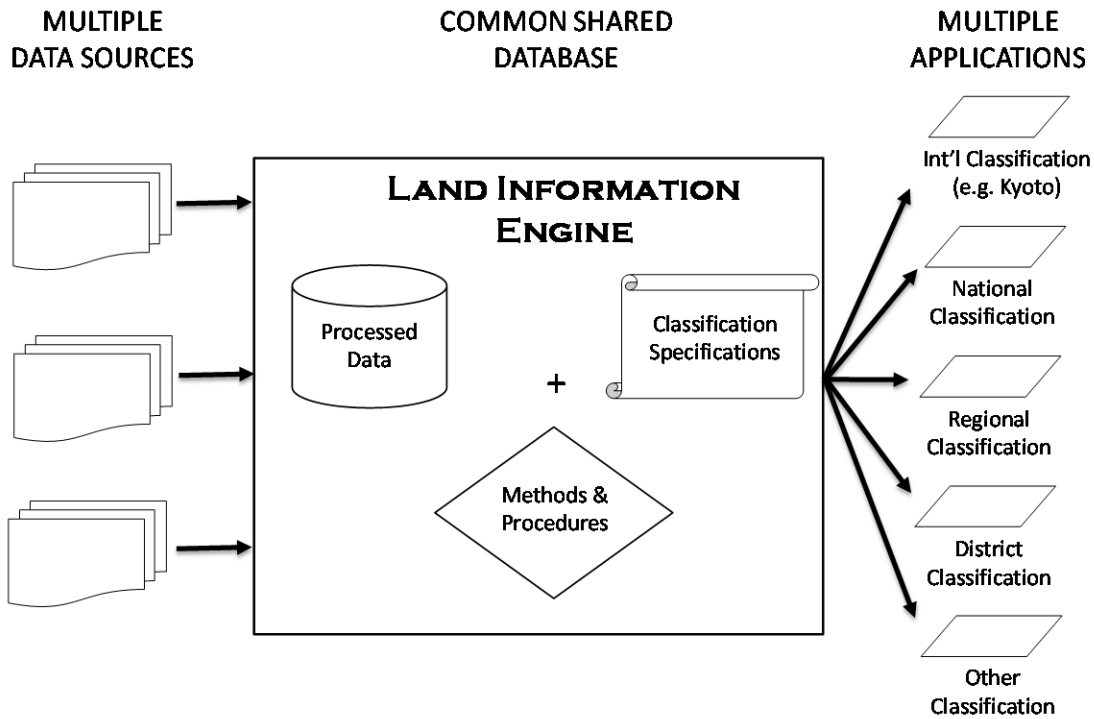

Figure 1 Conceptual approach for the land use database.

The database ("Land Information Engine" depicted in Figure 1) is intended to take advantage of emerging informatics approaches and standards for data, data protocols and interoperability, etc., that facilitate more flexible, adaptable, and verifiable approaches to environmental information management in general and, in this context, land-use information in particular.

3 Objectives

- Prepare a development case for the LUDB based on gaps and priorities identified from the recent Regional Council end-user survey
- Develop draft specifications for the LUDB for review by the LMF
- Finalise LUDB specifications in agreement with the LMF following their review.

4 LUDB Development Case

The LUDB development case is based on the results from the regional council survey as reported in Morgan et al. (2010). The results below are summary of those findings. Readers interested in the complete results should consult the full report.

4.1 End-User Survey

4.1.1 Gaps & Priorities

In the recent survey, regional council staff members identified several key gaps related to land-use information in New Zealand that broadly fall into five categories (Table 1). Based on a gap analysis, six key priorities emerged that the LUDB should address to begin to fill those gaps (Table 2).

It should be noted that the gaps and priorities listed primarily reflect the needs of regional councils, which reflect the purpose of the Envirolink fund. Other agencies and organizations within New Zealand will have their own needs that the LUDB might not initially address.

Table 1 Summary of key gaps identified by end-users in the recent survey

Gap	Summary
Consistency	• Need for consistency was most commonly cited by repsondents • A range of in-house, ad hoc approaches to information currently exist to meet the respondents' basic needs • Data typically lack the detail required to support confidence in decision-making • General desire for a more valid, accurate, reliable and consistent approach to land-use information backed by leadership and accountability
Detail	• Current sources lack information on practices, behaviours, and activities that constitute 'land use' • Inclusion of a range of detailed information on human activities is expected to lead to a greater ability to understand and manage land use • The way in which the proper level of detail can be captured, understood and displayed is problematic, with the level of detail potentially overwhelming a user • Capture of activity information raises questions related to privacy and proper use
Quality	• Quality varies widely based on information sources, some of which were not intended to be used as land-use information • Inferences about land use based on some data sources are problematic, especially when the quality of the source information is unknown • Variability in the use of existing sources is substantial • Desire for an increase in quality of attributes such as measuring and recording uncertainty in scale and attribute information to documentation data sources' lineage • LUDB could provide a more formal and streamlined process built on the current use of certain types of land-use information.
Spatial Scale	• Desire for finer resolution spatial information, often to farm and/or paddock scale • Existing information sources vary widely in scale and do not easily fit within a farm/paddock scale • Finer scales may not be immediately achievable, but preference exists to move towards finer scales going forward
Temporal Scale	• Land-use information should be current and regularly updated • Annual updates most often requested, although users recognised that frequency of update can vary based on context and need • Sources currently used are widely regarded as being out of date, e.g., LCDB2 is now over 8 years old • Data sources should be updateable and regularly maintained through updates, which is not common for the current information sources used

Table 2 Summary of key priorities and how the LUDB will address them

Priority	LUDB Features
Coordination & Consistency	• Consistency and coordination through developing, formalising and documenting processes with which land-use information is created • Formalised framework to ensure the coordination of data collection and the consistency of the resulting product • Processes for standards development, discussion, and approval • Flexibility to develop standards for specific purposes
Reliability – Accuracy	• Allows for on-going verification and documentation • May not initially improve the spatial or temporal accuracy of the land use classification given initial data limitations • Future accuracy of land-use should increase through the implementation of an atomised approach to data structuring & storage • Allows for historical and current use comparisons
Reliability – Updates	• Framework facilitates regular updating and incorporation of new information as data sources are updated and published • New information incorporated almost immediately • Incentivises – but does not guarantee – more regular updates
Scale – Spatial	• Flexibility permits input and output data at different spatial scales, subject to the finest resolution source data • Greater ability to incorporate spatial detail about all land uses, especially urban land use and land-use change • Potential to include many data sources including ad hoc ones to improve scale, such as building and resource consent information or high-resolution imagery
Scale – Temporal	• Examine land-use change at a range of time scales depending on the type of land-use change of interest • Updates at least annually • Able to export data at any time, for any purpose
Scale – Informational	• Accommodates data collected at fine informational detail • Intimately linked with the spatial/temporal scales of data collection such that finer scales are more costly and also raise privacy issues • Addressing this priority requires a long-term change in land-use information development. Informational scale will therefore receive less attention in the LUDB project

4.2 LUDB Development Case

Based on the results of the gap analysis and prioritization report, the LUDB must possess a number of characteristics including:

- *Flexibility* – accommodate a range of data input sources, land-use classifications, and associated methodologies
- *Adaptability* – able to evolve and accept new input data, methods, etc., over time
- *Memory* – store all input information, methods, classification schemes and associated metadata to allow regeneration of land-use information to go forward
- *Repeatable* – a user can generate land-use information on an as-needed basis
- *Authoritative* – holds metadata and other information documenting all processes undertaken to generate land use information, e.g., steps taken to generate a particular land-use classification are recorded for future reference, as opposed to just storing the classification itself.

5 Draft Database Design Considerations

To meet the priorities identified above and design a suitable LUDB to meet project objectives, a number of design considerations must be addressed. This section outlines those considerations, starting with a conceptual overview of the LUDB and then lists the specific considerations for consultation with LMF members within the scope of this project.

5.1 Conceptual Overview

The overall objective of the LUDB is to develop a way of encapsulating land use in a consistent framework. Conceptually the LUDB framework has several components (Figure 2). Structurally, the LUDB represents a formalised pathway to transform, input, process, store, analyse, generate, and disseminate land-use information.

As stated earlier, previous attempts at generating official land-use classifications in New Zealand failed because they focused on the classification. In other words, they spent considerable time scoping and defining a desired land-use classification with little thought or consideration for implementation. These efforts also made the mistake of trying to devise a single classification to suit any purpose.

The LUDB takes a much more practical, realistic, and feasible approach by first developing a general structure within which one can generate desired classifications *based on available data to suit specific needs or applications*. In the LUDB, the emphasis is on the framework, methods, procedures, and structures, rather than a particular classification. This has the advantages listed above in terms of flexibility, adaptability, repeatability, and authority. Most important, perhaps, is that the LUDB will retain all contributed data and will capture the processes used to generate land information layers, such that a particular land-use classification and/or data layer can be regenerated in the future.

Following Figure 1, each of the components are described in more detail, in order from top to bottom.

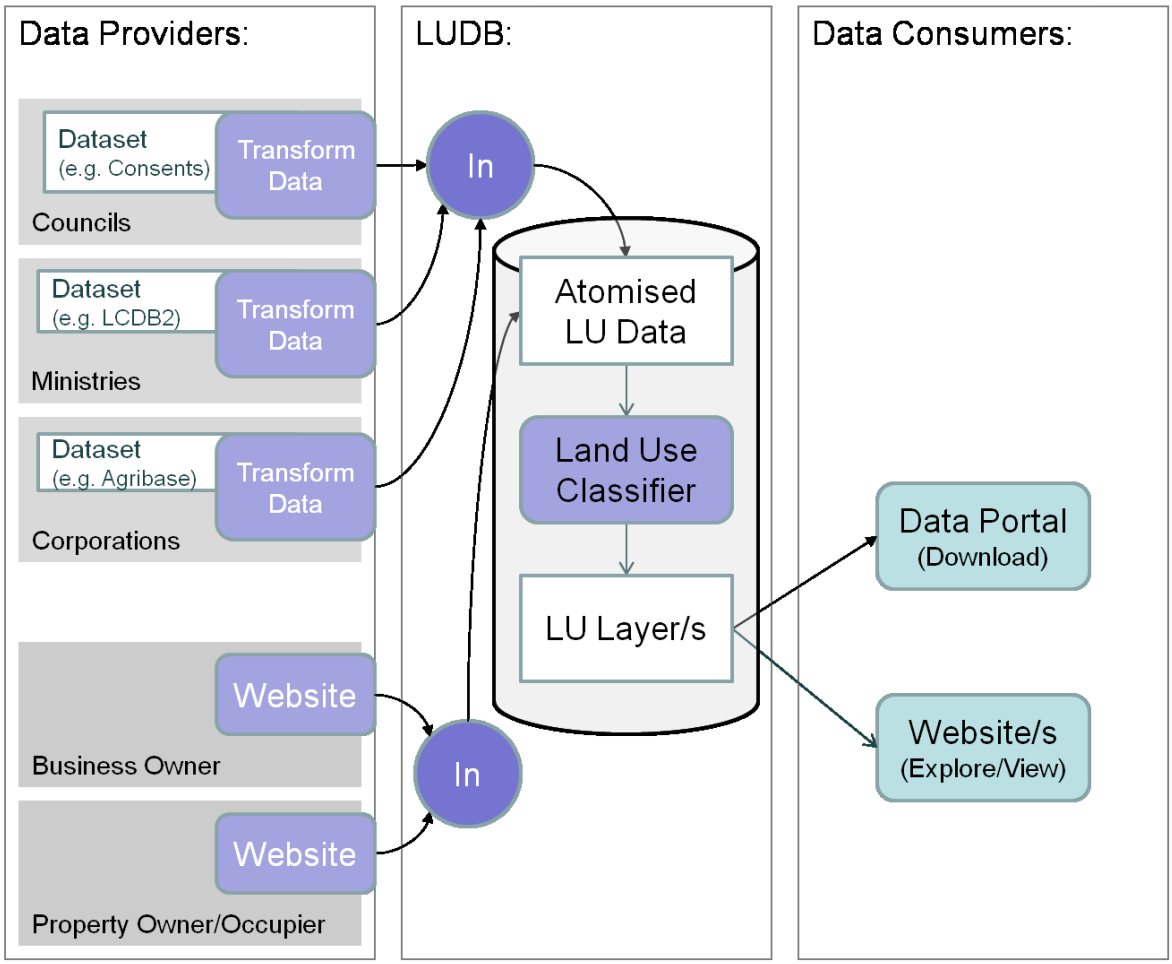

Figure 2 Conceptual diagram of the LUDB.

5.1.1 Transform Data

This component provides methods and procedures for transforming input source data into a form suitable for importing into the LUDB. The LUDB is not biased and would be capable of accepting a wide variety of information types such as geospatial data, relational database input, single records, or even verbal descriptions of land-use activities. Over time a library of pre-processing rules/scripts will be built that could be adapted and modified as input data evolve over time.

This step will vary widely depending on the nature, complexity, accuracy, etc., of the input data and to achieve desired gains in efficiency of storage, processing, etc.

5.1.2 Data Input ("In")

The Data Input component provides methods and procedures for importing transformed data into the LUDB, i.e. "data transport."

5.1.3 Atomised Land-Use Data

Imported land-use information that has been structurally transformed. The transformation includes:

- Spatial Transformation – dividing the data spatially into fundamental units based on an agreed spatial data reference layer, e.g., cadastral database
- Attribute Transformation – restructuring the data to conform to an agreed land use ontology, i.e. an explicit formal specification for how to represent land use. By doing this we will demonstrate that complex information can be stored using a relatively simple data structure. By simplifying the data structure we will facilitate the use of simple set theory logic to classify the data.

Data atomisation has several advantages, including: automatic tagging of the information to insure traceability; the tying of all land-use information to a specific place; the retention of both original information and subsequent re-interpretations; and the ability to link sets of observations in flexible ways.

5.1.4 Land-Use Classifier

Methods, rules and/or procedures for generating a particular land-use classification via processing and analysis of atomised land-use data. The land-use classifier operates on atomised data using rules to produce a data set and an associated classification and metadata that are subsequently available for use and distribution.

5.1.5 Land-Use Layer

Output land-use geospatial data layer generated by processing a particular land-use classifier. Different land-use classifiers would target different audiences and end-users. For example, some could be official classifications intended for State of Environment reporting, others might be catchment-specific land-use information such as those needed to undertake water quality modelling.

5.1.6 Data Portal

A web-based portal for accessing and downloading land-use data layers generated by the LUDB. Initially this will be a simple facility for discovering the land-use data layers.

5.1.7 Web Site

Web site for display of land-use information and (eventual) development of new methods and procedures to generate new land-use classifications and provide more advanced capabilities such as spatial and attribute search capabilities.

5.2 LUDB Development

In the long term we envisage that the LUDB could encompass data from a large number of data providers. It could borrow concepts and principles from social computer networking so that each data provider (owner) would retain control over their data. They can control who could view it, who could obtain it, and how it could be used. Similarly, different users could define their own classifications schemes to suit their own requirements and share classification schemes to meet shared requirements. For example, all regional councils could agree to a standard land-use classification for reporting purposes, while being able to generate purpose-built classifications to suit regional requirements. Furthermore, the LUDB could also allow for translation from one classification to the other, provided the same data were available. Eventually the LUDB could capture information volunteered by land owners/managers and significantly improve the quality, detail, and accuracy of land-use information throughout New Zealand.

In the short term (i.e. the duration of this project) the LUDB will initially have a more limited scope and functionality. In terms of the conceptual framework (Figure 1) we present below five design considerations to be addressed to deliver a first generation LUDB, i.e. LUDB-1G. The choice of appellation is borrowed from the terminology commonly used to describe systems with complex conceptual, methodological, and technical components, e.g., mobile phone networks. The analogy is apt because the LUDB is a system of interacting components that must effectively interoperate for LUDB to work. Going forward, we expect the LUDB to remain relatively stable for pragmatic operational purposes over several years and then be "upgraded" to subsequent generations (2G, 3G) as new concepts, methods, and technologies become available and are mainstreamed. Within the lifetime of one LUDB generation there could be several versions of a particular land-use information product. For example, we may see annual updates to a nationally agreed land-use classification to meet planning and reporting needs.

5.3 Consideration #1: Available Input Data Sources

What input data sources are available for use in LUDB-1G?

Given available resources, this project will restrict input data sets to those that are publically available and nationally consistent. Those include

- Land Cover Database
- Land Resource Inventory
- Land Environments of New Zealand
- Census.

In addition LMF members have been asked to identify and nominate 1-3 council-held data sources for possible inclusion in the LUDB. Those data sources must be nationally consistent or made to be so within the timeframe of the project.

5.4 Consideration #2: Data Transformation Procedures

What transformation tools need to be developed for available input data sources?

For each input data source we will develop a data transformation tool that pre-processes the database into a form suitable for input into the LUDB. Ideally, tools would be automated processes that run without assistance once completed. However, initial versions will most likely be semi-automated. Because data transformation procedures are dependent on the input data sources selected, they cannot be defined until those data sources are selected.

5.5 Consideration #3: LUDB Structure and Delivery Method

What is the preferred structure and delivery method of the LUDB?

The structure and delivery method are inter-related and eventually could consist of a complex system comprised of an array of technical and architectural solutions and approaches. For this project the LUDB will be simpler: it will initially deal only with a single workflow that processes a fixed set of input information using a single classification methodology to produce one nationally consistent spatial data layer meeting regional councils needs. Given this, there are two fundamentally distinct options for the LUDB structure and delivery:

A) Local Tool – the tool is distributed to end-users and installed in-house

B) Web Tool – end-user organisations access the tool on-line.

Selection of either A or B will influence the structure of the LUDB, as each relies on somewhat different architectures and technologies. Also each option has its own advantages and disadvantages (Table 3).

Table 3 Comparison of benefits and drawbacks of a Local Tool versus a Web Tool

Feature	Local Tool	Web Tool
Fully transparent	Yes	No
LUDB user can make changes (Add data, new classification, etc)	Yes (in theory)	No – initially Yes - eventually
Break everything by playing	Yes	No
Requires specific software and/or license to work (e.g., ArcGIS)	Maybe	No – but might need specific browser
Easier to update/upgrade	No	Yes
Less space required on client system	No	Yes

Regardless of which option is chosen, the LUDB will store data in an atomized fashion as described earlier. Input data will be spatially divided to match a common local boundary layer.

5.6 Consideration #4: National Geospatial Land-Use Layer Specifications

What are the specifications for the geospatial land-use layer that the project will deliver?

A key output of the LUDB project will be a first generation national land-use geospatial data layer. This requires agreement on a number of options including:

1. Format – Vector (Shapefile) or Raster (Grid)

2. Projection – New Zealand Transverse Mercator (better for Vector) or New Zealand Map Grid (better for Raster)

3. Resolution – desired spatial, temporal and informational resolution of the LUDB. Note that the 1G version will be constrained by the resolution of the available input data layers.

Based on discussions at the recent LMF workshop, LMF members indicated that they need to consult with other staff at their organisations to determine the preferred specifications for the geospatial data layer. There is a possibility that the LUDB may be able to deliver mutliple specifications, but that will require further investigation.

5.7 Consideration #5: National Land-use Classification

What land-use classification is desired?

While an agreed national land-use classification must be defined as part of the LUDB project, this classification and its associated geospatial land-use layers do not constitute the entire LUDB. The LUDB itself includes the overall system framework; component modules necessary to allow land-use data to be collected, aggregated, reclassified, and made available; and different instances of classification schemes and rules for generating a particular land-use classification and associated geospatial land-use layer.

Development of a preferred nationally consistent, cross-council land-use classification is the subject of a separate concurrent work stream within the project. However we have included information on six existing land-use classifications in this report for LMF members to reference as they consider their land-use classification needs. For each classification we present a brief review of the purpose, data requirements and to provide a starting point for defining a robust land-use classification for the LUDB project. The six classifications reviewed were:

- Land Use New Zealand (LUNZ)
- Creating Futures
- AgriBase

- Land Use for Water Quality ECan's LU Classification
- LINZ Valuation Rules Land Use
- LUCAS: Land Use and Carbon Analysis System

This information is being made available for review and consideration by the LMF members. Development of a preferred land-use classification is the focus of a concurrent discussion with LMF members.

5.7.1 Land Use New Zealand (LUNZ) (2004)

Purpose

Land Use New Zealand (LUNZ) was developed to provide land-use information for the Catchment Land Use for Environmental Sustainability (CLUES) project (Woods et al. 2006). CLUES models the impacts on water quality at a selected point in a river network as a result of changes in land use occurring upstream. LUNZ addressed the need for a nationally consistent representation of (predominantly rural) land use.

LUNZ had three purposes:

- Create a classification that satisfies the needs of both landscape-scale models and farm-scale models
- Determine the best estimate of land use nationally
- Describe farms in terms that can be related to one or a mixture of MAF Monitor Farm types.

Data

LUNZ was produced by combining information from four sources:

- *AgriBase* – a database of information collected by AsureQuality to form MAF Monitor Farm models. Each Monitor Farm model is based on a survey of 20–30 farms from a particular locality
- *Land Cover Database 2* – a national map of land cover derived from satellite imagery from 2001/2002 at nominally 1-ha spatial resolution (i.e. minimum mapping unit) (Thompson et al. 2003)
- *Land Resource Inventory* – a national map identifying land units with similar biophysical and land productivity characteristics
- *Land Environments of New Zealand* – a national hierarchical classification of New Zealand's terrestrial environments based on a combination of 15 climate, landform, and soils variables (Leathwick et al. 2003a, b).

In theory, AgriBase provides sufficient information to derive adequate land-use information for all farm land across New Zealand. Unfortunately, the design of the dataset had several problems that prevented it from fulfilling this function:

- Many farmers do not fill in all the attributes in AgriBase relevant to their farm enterprise, in particular the area occupied by animals is more often left blank than filled in
- For many farms the reported farm size does not agree with the computed area derived from the cadastral polygons associated with the farm, implying that many of the other activities reported on the farm do not necessarily occur within the farm boundary
- Reporting on type of farm is inconsistent and reflects either a farmer's primary source of income or profit or alternatively the predominant area or even the preferred or dominant activity of the farmer.

The combination of these inconsistencies made it impractical to rely on AgriBase alone to determine stock units per hectare or any other management function that can be related to measures used in the MAF Monitor Farm spreadsheets. A hierarchical land-use classification was therefore developed, and a corresponding national geospatial land-use layer was produced using a complex algorithm that estimated the probability for different land-use types to occur at any particular location within New Zealand based on the combination of input sources.

Classification

The classification for LUNZ is hierarchical, with four tiers that gradually increase in the level of land use detail. Hence each parcel of land assessed by LUNZ contains four Land Use designations, depending on the Tier. The detailed database rules through which the above data are used to delineate land use types are explained in Wydler (2010). A visual representation of the hierarchical tiers for LUNZ can be seen in the Appendix. Note the Land Use Classification Key at the base of the image, which enables a basic understanding of the data types used in the classification for each class/Tier.

One key point that should be acknowledged is that because AgriBase was used as a direct data source for the LUNZ project, a number of the categories are identical or have strong links to the categories from LUNZ.

Tier I focuses on the key land coverage areas within the productive agricultural landscape of New Zealand (e.g., pastoral, arable, horticultural, etc.) with respect to farming. Five land-use categories are available at this stage: Pastoral, Arable, Horticultural, Forestry, Native Forest, and Other.

Tier II focuses on a more defined delineation of the Tier I land use categories with key focus on animal type (Pastoral), crop type (Arable), fruit type (Horticultural), and non-productive land (Other). The differentiation found in these Tier I classes are outlined in Table 4. There are no Tier II categories for the Forestry and Native Forest, Tier I categories.

Tier III primarily focuses on the regional differences in Pastoral Farming. The three Tier II Sheep & Beef categories contain the greatest regional differentiation, with Deer only having a North Island and South Island split at the Tier III level. The Tier II Dairy class is split into a Drystock class alongside six regionalised classes. Outside the Pastoral Farming land use, only Pipfruit and Viticulture have Tier III classes – both are regionalised classes focusing on Horticultural hotspots, Hawke's Bay, Nelson and Marlborough.

Tier IV classes contains the most detailed information concerning the land-use classification, with detailed pastoral farming types listed (Alpaca, Dog, Donkey, Emu, Goat, Horse, Ostrich, Pig, and Poultry). Arable crops are defined as the type of crop and/or vegetables grown. The Tier I Forest and Native Forest classes are defined in more detail at Tier IV alongside an increase in classes for the Tier II "Other" classes.

Table 4 LUNZ Tier II land-use classes

Pastoral	Arable	Horticultural	Other
Sheep & Beef Intensive	Arable Crops	Flowers	Artificial
Sheep & Beef Mountain	Process & Fresh Veges	Export Berry	Bare Ground
Sheep & Beef Hill Country	Other	Tropical Fruit	Water Bodies / Rivers
Deer		Kiwifruit	Wetlands
Dairy		Summer-Fruit	Scrubs
Other Animals		Pipfruit	
		Viticulture	

5.7.2 Creating Futures Land-Use Layer

Purpose

The land-use layer within the Creating Futures WISE (Waikato Integrated Scenario Explorer) model provides the initial land-use starting point for the Scenario Explorer. Using a cellular automata land-use change model, the land-use layer is altered based on demands for land use as determine by economic and demographic models.

Data

The data sources used in the creation of Creating Futures land-use layer included the land cover database, ratings valuation database, protected-areas network database (Rutledge et al. 2008), and several spatial data layers held by Environment Waikato including Land Use layer. As stated in Rutledge et al. (2010), the full database and associated algorithms used to generate the land-use layer are available from Environment Waikato, although not all input layers may be publically available.

Classification

The Creating Futures land-use classification is a categorical classification consisting of 28 land use classes, although only 27 were used in the final WISE model (Table 5). It is important to note that of the 27 layers used in the initial land-use layer, two are used primarily as spatial context and have no weight in the final land-use layer (Land outside the Study Area, Marine outside the Study area). The full classification with class descriptions, examples (limited to the Waikato region), and rationales for inclusion are appended at the end

of this document. While the rules and data sources that are used to create this layer are not documented here, the actual classification itself is comprehensive and easily understood.

Table 5 Creating Futures land-use classification

Airports	Land Outside Study Area	Residential Lifestyle Blocks
Aquaculture	Marine	Residential – Low Density
Bare Surfaces	Marine Outside Study Area	Residential – Medium to High Density
Biofuel Cropping	Mines and Quarries	Sheep, Beef or Deer Farming
Commercial	Indigenous Vegetation	Transport Services (not used)
Community Services	Manufacturing	Urban Parks and Recreation
Dairy Farming	Marine	Utilities
Forestry	Other Agriculture	Vegetable Cropping
Fresh Water	Other Cropping	Wetlands
Horticulture	Other Exotic Vegetation	

5.7.3 AgriBase™

Purpose

AgriBase is a commercial product originally developed as a geospatial information dataset to enable MAF to plan, notify and protect for agricultural diseases such as Foot and Mouth. Development of the AgriBase™ system began in late 1988, and national data capture began in 1993. AgriBase™ records are maintained by AsureQuality New Zealand Ltd through routine contact with farmers and through updates of property changes from Valuation Service Providers. The AgriBase™ database holds information on all types of rural properties such as farms, vineyards, orchards, forests, and small holdings and includes contact details for the individuals that own and manage them.

Data

The data used to create AgriBase™ have been collected directly from farmers through voluntary registrations, mostly within the past three years. AsureQuality cannot guarantee breadth of coverage of registrations due to the voluntary nature of AgriBase™ registrations.

While all farm locations and contact details for the owners have been collected and documented, farm-type data (including stock types and numbers, home and farm gate locations, and the ownership/in practice situation) in AgriBase™ are not complete. The incomplete nature of the database is primarily because of the 'voluntary' nature of the data collection through surveys and information requests directly to the farmers.

The voluntary nature of the responses results in both area and attribute discrepancies, for example, the area the farmers state versus the area of the farm calculated from the cadastral information. Spatial discrepancies result from farmers reporting farm area in different ways (i.e. effective pastoral area vs total farm area). The spatial accuracy of the farm boundaries reflects the underlying accuracy of the LINZ cadastral information. Accuracy of attributes,

including contact details, stock numbers and farm sizes, is dependent on survey data provided by farmers and on checks by AsureQuality New Zealand Ltd for anomalies. AsureQuality assume respondents are honest in their survey responses. Property detail information, including subdivision, is obtained from Quotable Value New Zealand.

Classification

The land-use classification for AgriBase™ highlights the key focus on primary production. There are two types of classification, Farm Type and Farm Enterprise. The higher level Farm Type classification is categorical. Based on the Farm Types listed there are some key high level differentiations within the 34 Farm Type classes.

The Farm Enterprise classification appears to be hierarchical, with 37 Farm Enterprise classes being asymmetrically split into a total of 161 land-use classes. Vegatable Growing has the largest number of subclasses with 54, while Other Fruit (13), Arable (12), and Forestry (12) are the only other classes with more than 10 subclasses.

Both AgriBase™ classifications are provided in the Appendix.

5.7.4 Environment Canterbury Land Use for Water Quality

Purpose

The Land Use for Water Quality (LUWQ) project aims to create a range of scenarios that will enable options for management of water quality in Canterbury to be developed. These scenarios are focused on the productive land within the Canterbury region and developed as a result of the rise in intensified agricultural land alongside the increasing evidence of a general decline in the quality and health of the region's freshwater resources (Environment Canterbury 2008). This general decline is primarily attributed to the cumulative effects of non-point source discharges from agricultural land use. The initial stages of the LUWQ project have focused on the future outcomes for the Hurunui catchment in northern Canterbury.

Data

The data used to create this land use layer are diverse: AgriBase, the Land Cover Database (LCDB2), and 1:50 000 topographic maps, plus a map of irrigation derived from consent information, and/or from remote sensing. The rules through which the AgriBase information was linked to the nitrate leaching land-use categories were complex, but have been formalised into rule sets to ensure consistency. LCDB2 was used to supplement the 'holes' in the AgriBase information (see AgriBase discussion above for details). Topographic information sourced from LINZ was used to define and locate non-productive areas that were not present in AgriBase and LCDB2 such as golf courses.

Finally, the existing irrigated areas within the catchment were mapped using both the Environment Canterbury Resource Consent Database and a supplementary remote sensing

approach. The resulting 'Irrigation Areas' map has as yet only been prepared for the Hurunui catchment but the methodology is expected to be applied across the region.

Classification

The classification itself was defined based on a communal workshop held on 15 May 2008. Like most classifications, there is an underlying purpose to the land-use classification created for the LUWQ project. The main focus of the LUWQ project was the transport of nitrate into the catchment's freshwater resources. The aim of the workshop was to define a 'lookup table' of leaching rates of the various land-use/soil/rainfall combinations as required by the predictions tools.

As a result, the participants of the workshop "defined a set of key land uses/management relevant to nitrate leaching" (Hill et al. 2010). The resulting land-use layer used in the LUWQ scenarios aims to map these categories. Hill et al. (2010) also detail some of the considerations that were made when defining the land-use classification:

- the variety of land uses found across the region
- available land-use databases with information at a field or property scale
- key stocking levels likely to affect the amount of nitrate leached
- the variety of arable land-use combinations.

Because the project focused on the leaching of nitrate into the freshwater resources of the catchment, the resulting classification is highly focused on productive land uses, with only three of the 27 land use classes not being aligned to pastoral, arable or horticultural uses.

It is interesting to note that the classification aims to categorise activities on dairy land, with a range of stocking rates and seasonal differences. Hill et al. (2010) note that these types of land use were difficult to map based on the lack of data at a sufficient level of detail.

The Appendix contains the full LUWQ classification.

5.7.5 LINZ Rating Valuation Rules

Purpose

The LINZ rating valuation rules are meant to ensure a nationally consistent, impartial, independent, and equitable rating valuation system that can be monitored and audited. Of the range of rules within the rating valuation, one specific section (confusingly titled 'Land Use') contains a land-use classification. Unfortunately, gauging the reliability of the land-use component of the valuation information is very difficult, given the number of territorial authorities, valuation organisations and valuers involved in the process.

Data

Under the Ratings Valuation Act of 1998, territorial authorities must prepare and maintain a district valuation roll. Councils usually contract this work out to one of several valuation firms. Based on discussions, councils gift the information to the valuers in exchange for a substantially reduced fee. This enables the valuers to resell the information into the wider public. Valuations do not require an actual site visit to view the site. Most are done alongside their neighbouring properties on a semi-annual basis.

Classification

The land-use section of the rating valuation includes aspects of both land use as represented by activities and zoning and land cover as represented by various built environment attributes, for example, floor area, construction materials. The LINZ rating system therefore constitutes a multi-dimensional classification that captures multiple attributes for each rating unit.

The assessment includes 9 attributes of information that must be recorded for every rating unit; within the valuation a record of 'Actual Property Use' is required. It is this attribute that begins to constitute a land-use classification in line with the other land-use classification discussed in this document.

The LINZ rating valuation rules (2008) explains that the "actual property use means the activity, or group of interdependent activities having a common purpose, performed on land or building floor space at the date of inspection" (p. 44). The land-use classification is recorded as a two-character alpha numeric code, to create both a primary and secondary levels of the land-use classification. The classification outlined in the LINZ rating valuation rules (2008) enables multi-use situations to be recorded accurately.

With the need to categorise all New Zealand's land use, the classification is the most diverse, with a range of categories covering all types of land use (Table 6). The only land uses that appear to be missing are more natural land uses such as forestry or native forest. With the general nature of the classification being so diverse, the level of detail within the land use groups is lacking for certain areas.

All the primary and secondary land-use types for Actual Property use class within the LINZ rating valuation rules can be reviewed in the Appendix.

Table 6 LINZ Rating Valuation primary level land-use classification

Commercial	Recreational
Community Services	Residential
Industrial	Rural industry
Lifestyle	Transport
Multi-use at Primary Level	Utility Services

5.7.6 LUCAS: Land Use and Carbon Analysis System

Purpose

For the Land Use and Carbon Analysis System (LUCAS) project a number of land-use classes were defined to enable the developemnt of New Zealand wide maps of land use as at 1990, 2008 and 2012. Using these maps, land-use changes between the reference year (1990) and a number of time-steps defined through the Kyoto Protocol (2008 and 2012) can be evaluated to calculate the changes in land use and the resulting change in carbon emissions. The land-use classes were required to be logically consistent between the reference year and the comparison year, hence the land-use classes are high level broad categories that focus on land-use changes in Forest, Grassland, Cropland, and Wetland land uses.

Data

The data that contribute to the Land Use layer are derived primarily from satellite imagery and aerial photography. The satellite imagery and aerial photography were used to define the extent of four of the twelve classes in the land-use classification (Natural Forest, Pre-1990 Planted Forest, Post-1989 Forest, and Grassland with woody biomass); the remaining eight land uses are derived from pre-existing datasets such as the New Zealand Land Cover Database versions 1 & 2 (LCDB) and New Zealand Land Resource Inventory (NZLRI).

The 1990 land-use map is derived from Landsat 4 and Landsat 5 satellite imagery taken between November 1988 and February 1993. Using this information the land-use classification process was developed to map woody biomass classes into the land-use subcategories being used for reporting. The classification process was validated and improved using Landsat 7 ETM+ imagery acquired in 2000–2001, and SPOT 2 and 3 data acquired in 1996–1997. Additional higher resolution imagery (mainly regional-scale aerial photography) was used to increase the confidence of some land-use mapping decisions.

Classification

The classification used for LUCAS is flat (rather than hierarchical), although the system has a pseudo-hierarchical look to it based on the repeated use of the four core land-use types (Forest, Grassland, Cropland and Wetland) (Table 7). An example of this is the three land-use classes under the heading of ‘Grassland’: ‘Grassland – with woody biomass’; ‘Grassland – high producing’; and ‘Grassland – low producing’.

Most of the twelve land-use classes are straightforwardly defined, though the Forestry classes include a temporal component to define new forestry areas post-1989. The twelve classes are defined in the Appendix. Further details can be found in the LUCAS land-use mapping data description document (http://www.mfe.govt.nz/issues/climate/lucas/data/lucas-lum-1990-2008-v003-nz-data-description.pdf).

Table 7 LUCAS basic land-use classification

Natural Forest	Cropland – perennial
Pre-1990 Planted Forest	Cropland – annual
Post-1989 Forest (2008 only)	Wetland – open water
Grassland – with woody biomass	Wetlands
Grassland – high producing	Settlements
Grassland – low producing	Other

6 Next Steps

The report outlines five key considerations for the design of the LUDB that LMF members must consider. The next step are as follows:

1. Report cirulcated to LMF members for review and consideration with an accompanying worksheet that helps guide LMF members through the steps needed to address the design considerations

2. LMF members address the design considerations outlined in the report

3. LMF members and project team members discuss the five key design considerations at a workshop in February 2011 and agree a set of preferred alternatives, including a draft national land-use classification

4. Project team members finalise database design and the draft land-use classification based on feedback received and workshop discussions and circulate them to LMF members.

7 Acknowledgements

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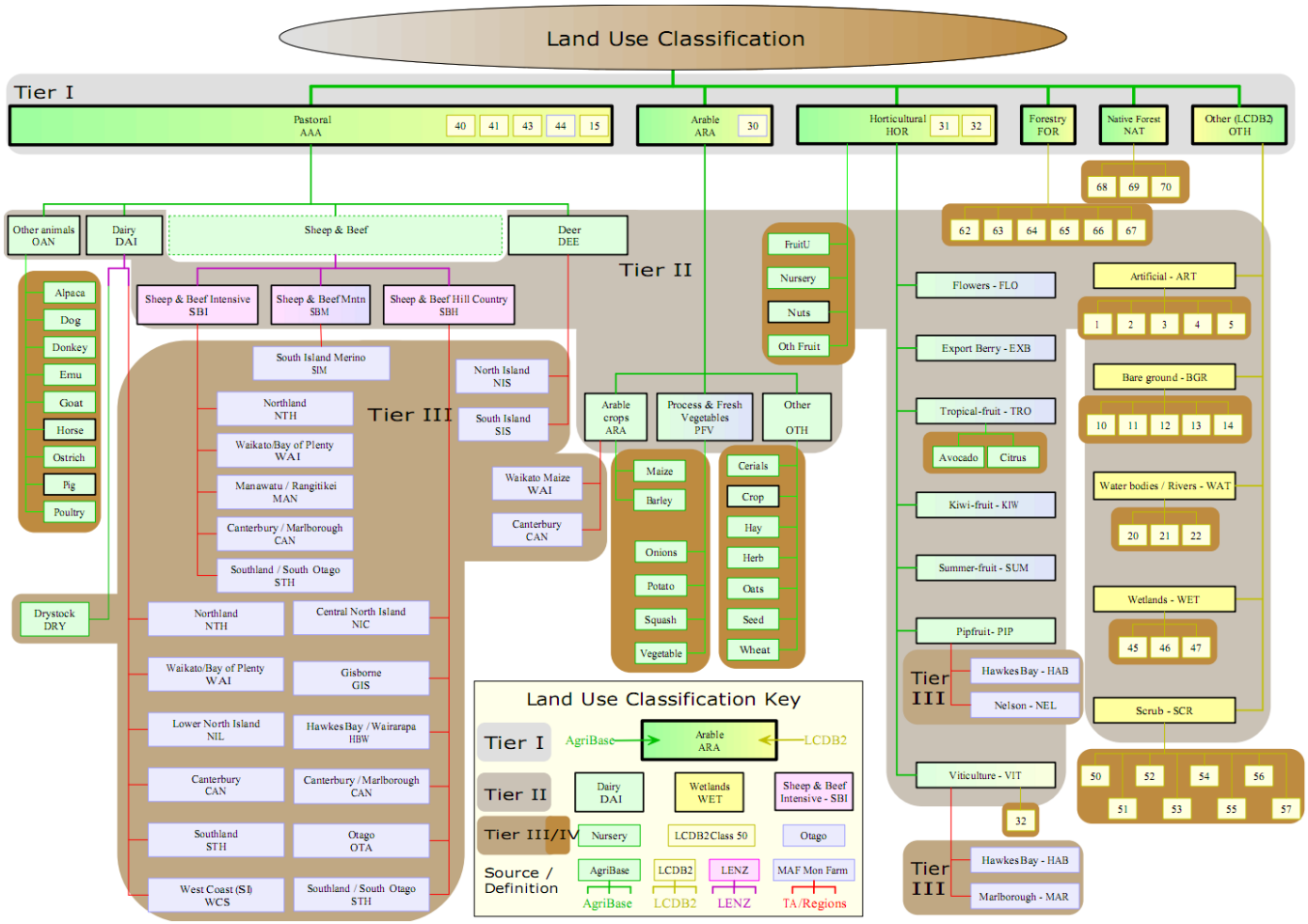
Appendix – Land-Use Classifications

LUNZ: Land Use New Zealand Classification



Creating Futures WISE Land Use Classification

Cell Value	Type	Class	Code	Description	Examples	Rationale
0	Vacant	Bare Surfaces	BSF	Sand, unvegetated sand dunes, bare rock, ice and snow, large unvegetated erosion scars and alluvial flats, permanent exposed soil not related to mine or quarry activities	Beaches and sand dunes on the Coromandel and West Coast, The volcanoes of Tongariro National Park	Covers significant parts of Waikato coastline and around mountains. Is a passively dynamic land use of natural causes
1		Indigenous Vegetation	IDV	Predominantly native vegetation such as indigenous forest, shrubland, tussock and mangroves	Indigenous forests, manuka/kanuka, flaxland, fernland, etc.	"Native bush" is an iconic part of the NZ landscape; also indigenous forest has second highest coverage in Waikato region
2		Other Exotic Vegetation	OEV	Predominantly exotic/non-native vegetation not intentionally planted for production of timber products	Wilding pines, willows, deciduous hardwoods, gorse, blackberry, heather, matagouri? Why query?	Allows for areas where non-natives exist or can colonise after management for economic gain stops (similar to abandonment in other RIKS models but that concept does not fit as well in NZ)
3		Wetland	WLD	Permanent saline or freshwater wetlands and their associated non-woody vegetation	Whangamarino; Torehape; Kopuatai; Some estuarine margins	Although officially protected, inclusion as vacant state allows for possibility of further loss or restoration, both of which occur; difficulty with resolution as many wetlands may fall below the resolution of the model
4	Function	Residential – Lifestyle Blocks	RLB	Very low density, detached, private, single-family dwellings on lots >0.25 ha but usually no larger than 8 ha; usually located in peri-urban or rural areas	Developments around Matangi, Tamahere, River Road north of Hamilton and NW of Cambridge	For the Waikato, 2 classes (low/high) for depicting lifestyle/periurban vs. urban situations would likely suffice; 3 classes are recommended for easier transferability to other regions, such as

Cell Value	Type	Class	Code	Description	Examples	Rationale
5		Residential – Low Density	RLW	Areas with 5–25 dwellings per hectare, typically dominated by detached, single-family dwellings or duplexs; lot sizes typically from 500–1000 sq metres but can be up to 2500 sq metres	This is typical New Zealand residential development (i.e. "the Kiwi quarter-acre dream") built mostly prior to 2000	Auckland or Wellington, where 3 classes better capture the range of densities available or allows for more scrutiny of intensification
6		Residential – Medium to High Density	RMH	Areas with >25 dwellings per hectare, typically dominated by multi-unit buildings like townhouses, apartment complexes, or high-rises	Sherwood Vale in Hamilton (along Ruakura Road); new developments north of Hamilton; apartment blocks	
7		Commercial	CML	Wholesale and Retail Trade, Accommodation/Restaurants /Cafes, most communication services, Finance/Insurance and Property Services; Services to Agriculture; Hunting and Trapping	The Base, any CBD or shopping center in Hamilton or other city/town	A key land-use class in terms of its influence on other urban land uses. Typically is the centre of any urban area
8		Community Services	CMS	Government Administration and Defence; Education; Public Safety; Health Services; Public Film, Video, Radio and Television services; Libraries, Museums, Arts and services to the Arts	Waikato District Hospital, Waikeria Prison (Buildings), Hamilton Boys High School, Police Station	A key land use in the service of urban areas. Typically borders commercial and is actively dynamic in expanding urban areas
9		Horticulture	HOR	Production of fruits, nuts, seeds and flowers and other ornamental plants; includes nurseries and viticulture	Vilagrads and Mystery Creek Vineyards; Sunfruit Orchards	Pastoral-based production is the dominant land use in the Waikato Region, followed by forestry. Cropping and horticulture generally make up a smaller part of the region although they can be significant in terms of their effects on land and water. Biofuel cropping is
10		Biofuel Cropping	CPB	Production of plants for energy supply	Rape seed, Jatropha, Beets, Sorghum, Coppice plantations, maize? (see issues), etc.	

Cell Value	Type	Class	Code	Description	Examples	Rationale
11		Vegetable Cropping	CPV	Production of plants and roots for the purpose of vegetables for human consumption. Typically involves heavy soil disturbance as part of succession cropping	Land around Pukekohe?	included to allow for expansion in future scenarios
12		Other Cropping	CPO	Production of other crops such silage, barely, maize, wheat, tobacco, hops; fungi. Usually involve less disturbance of the soil and rotated on an annual basis	Various rural locations around the region	
13		Dairy Farming	DFM	Land used for the pastoral production of dairy milk or for support of that land use	Most of Waikato's low-lying pastoral landscape	
14		Sheep, Beef or Deer Farming	SBD	Pastoral production of sheep and/or beef and/or deer	Predominantly hill country farming such as commonly found around Te Kuiti	
15		Other Agriculture	OAG	Other agricultural activities such as beekeeping, horse, pig, poultry mixed livestock and other livestock farming	Equine industry around Cambridge; Goats, Pigs, Chickens, Ostriches, Alpaca	
16		Forestry	FTY	Land used for the growth and harvesting of wood, primarily Radiata Pine but also may include other exotic or indigenous species	Kaingaroa or Kinleith Forest. Various smaller private forestry blocks on farmland	

Cell Value	Type	Class	Code	Description	Examples	Rationale
17		Manufacturing	MFG	Production and storage of goods such as wood/paper, textiles, clothing, footwear, foods, beverages, petroleum, coal, chemicals, metals and non-metals, machinery, equipment and furniture; printing and publishing	Kinleith Pulp and Paper Mill; Dairy Factories; Urban industrial areas	A key land use in terms of its interactions with primary production land uses and the urban land uses serving the manufacturing area
18	Feature	Marine	MAR	Estuarine and open coastal water out to the 12NM regional boundary	West Coast, Firth of Thames, Coast around Coromandel Penninsula, Raglan Harbour, Whangamata Estuary	A significant part of the Waikato region generally deemed static but could change to a vacant state if aquaculture became a function. Has neighbourhood influences on some land uses
19		Aquaculture	AQC	Production and cultivation of aquatic animals and plants; both salt and fresh water	Mussel farms off Thames coast. Huka prawn park	A developing industry in the Waikato Region. Difficult to model as a function at this stage due to a lack of information but could be changed to a function in later versions
20		Utilities	UTL	Infrastructure for generation, transmission, distribution, storage, treatment or manufacture of electricity, gas, water supply and wastewater treatment. Also includes large infrastructure associated with transportation but not airports	Huntly Power Station, Karapiro Dam, Hamilton Wastewater Plant, Wairakei Geothermal Power Plant, Frankton Railway Station	Critical in keeping the built human environment although tends to have only minor interactions with neighbouring land uses
21		Mines and Quarries	MAQ	Mining and quarrying operations and their solid waste products. Includes coal, oil and gas extraction and exploration activities	Huntly Coal Mine, Waihi Gold Mine; various sand & gravel quarries	Covers significant parts of the Waikato Region. A key employer

Cell Value	Type	Class	Code	Description	Examples	Rationale
22		Urban Parks and Recreation	URP	Areas set aside for recreation, leisure activities, or aesthetic enjoyment; includes parks and gardens, sports fields and facilites, gambling and other recreation services. Excludes conservation estate land such as National or State Forest Parks	Claudelands Park, Cambridge Town Belt, Hamilton Gardens, Waikato University grounds, Waikato Stadium, Te Rapa Racetrack	Has strong impacts on urban land use dymanics
23		Fresh Water	FRS	Permanent fresh water bodies including lakes, reservoirs, dams and ponds over 4 ha and rivers wider than 200 m	Lake Taupo, Lake Karapiro, various smaller lakes and ponds 4 ha minimum	Covers significant parts of the region and has some interaction with some neighbouring land uses
24		Airports	APT	Large airports used for domestic or international flights and their directly associated structures and buildings. Excludes small rural airports and airstrips used only for recreational or primary industry purposes.	Hamilton, Taupo and Thames airports	Critical in servicing large urban areas. Has immediate interactions with some neighbouring land uses
25		Land Outside Study Area				
26		Marine Outside Study Area				

AgriBase Farm Type and Farm Enterprise Classification

Farm Type	Farm Enterprise		
Class	**Class**	**No. of subclasses included**	**Description**
Alpaca and/or Llama Breeding	AAA_HA	1	Land area devoted to livestock
Beekeeping and hives	ARA_HA	12	Arable Land
Arable cropping or seed production	BEF_Nos	6	Beef cattle numbers
Beef cattle farming	BERR_HA	1	Berry fruit
Dairy cattle farming	BIS_Nos	1	Bison numbers
Deer farming	CAM_Nos	2	Camelids (Alpacas and Llamas)
Dogs	CITR_HA	1	Citrus fruit
Dairy dry stock	DAI_Nos	5	Dairy Cattle numbers
Emu bird farming	DEE_Nos	6	Deer numbers
Fish, Marine fish farming, hatcheries	DOG_Nos	1	Dogs
Flowers	DONK_Nos	1	Donkeys
Forestry	DUCK_Nos	1	Ducks
Fruit growing	EMU_Nos	1	Emus
Goat farming	FLOW_HA	1	Flowers
Grazing other peoples stock	FODD_HA	3	Fodder
Horse farming and breeding	FOR_HA	12	Forestry
Lifestyle block	FRU_HA	1	Undefined Fruit
Native Bush	GOAT_Nos	1	Goats farmed
New Record – Unconfirmed Farm Type	GRAZ_HA	1	Grazing Other People's Stock
Not farmed (i.e. idle land or non-farm use)	HERB_HA	1	Herbs/Medicinal Plants
Plant Nurseries	HORS_Nos	1	Horse numbers

Farm Type	Farm Enterprise		
Class	**Class**	**No. of subclasses included**	**Description**
Other livestock (not covered by other types)	KIWF_HA	3	Kiwifruit Orchards
Other planted types (not covered by other types)	NAT_HA	1	Native Bush
Ostrich bird farming	NURS_HA	1	Nursery
Enterprises not covered by other classifications	NUTS_HA	1	Nuts
Pig farming	OANM_Nos	1	Other Animals
Poultry farming	OFRU_HA	13	Other Fruit
Sheep farming	OLAN_HA	2	Other Land Use
Mixed Sheep and Beef farming	OSTR_Nos	1	Ostrich numbers
Tourism (i.e. camping ground, motel)	OTH_HA	2	Idle land or planned for redevelopment
Unspecified (i.e. farmer did not give indication)	PIGS_Nos	2	Pig numbers
Vegetable growing	PIPF_HA	4	Pipfruit
Viticulture, grape growing and wine	POU_Nos	4	Poultry birds
Zoological gardens	SHP_Nos	5	Sheep numbers
	STON_HA	6	Stone Fruit
	VEG_HA	54	Vegetable Growing
	VITI_HA	1	Viticulture

Environment Canterbury LUWQ land-use classification from Canterbury Regional Environment Report (Environment Canterbury, 2008)

Apples	Forestry – Exotic
Arable: Continuous Irrigated & Dryland	Forestry – Native
Arable: Mixed Grazing Irrigated & Dryland	Golf course
Arable: Seasonal Grazing Irrigated & Dryland	Grapes
Beef: 100% Irrigated & Dryland	Horses
Berry	Lifestyle pastoral
Commercial Vegetable	Pigs
Dairy: 3 cows/ha, winter on	Sheep: Irrigated & Dryland
Dairy: 3 cows/ha, winter off	Sheep/Beef: 10% beef, Irrigated & Dryland
Dairy: 4 cows/ha winter on	Sheep/Beef: 20% beef, Irrigated & Dryland
Dairy: 4 cows/ha, winter off	Summer fruit
Dairy: 5 cows/ha winter off	Unspecified fruit, mixed fruit
Dairy: Support	Urban or settlements
Deer: Irrigated & Dryland	

LINZ Rating Valuation Rules for Actual Property Use

Primary level Land Use	Code	Secondary level Land Use 0	1	2	3	4	5	6	7	8	9
Multi-use at the primary level	0	Vacant or intermediate	Rural industry	Lifestyle	Transport	Community services	Recreational	Utility services	Industrial	Commercial	Residential
Rural industry	1	Multi-use within rural industry	Dairy	Stock finishing	Arable farming	Store livestock	Market gardens and orchards	Specialist livestock	Forestry	Mineral extraction	Vacant
Lifestyle	2	Multi-use within lifestyle	Single unit	Multi-unit							Vacant
Transport	3	Multi-use within transport	Road transport	Parking	Rail transport	Water transport	Air transport				Vacant
Community services	4	Multi-use within community services	Educational	Medical and allied	Personal and property protection	Religious	Defence	Halls	Cemeteries and crematoria		Vacant
Recreational	5	Multi-use within recreational	Entertainment	Active indoor	Active outdoor	Passive indoor	Passive outdoor				Vacant
Utility services	6	Multi-use within utility services	Communications	Electricity	Gas	Water supply	Sanitary	Other	Postboxes		Vacant
Industrial	7	Multi-use within industrial	Food, drink, and tobacco	Textiles, leather, and fur	Timber products and furniture	Building materials other than timber	Engineering, metalworking, appliances, and machinery	Chemicals, plastics, rubber, and paper	Other industries, including storage	Depots and yards	Vacant
Commercial	8	Multi-use within commercial	Retail	Services	Wholesale	Offices	Car parking				Vacant
Residential	9	Multi-use within residential	Single unit excluding bach	Multi-unit	Public communal unlicensed	Public communal licensed	Special accommodation	Communal residence dependent on other use	Bach	Car parking	Vacant

LUCAS: Land Use and Carbon Analysis System Land-use Classification (from Looking at LUCAS: LUCAS – Data Description)

Natural Forest	• **Tall forest on Department of Conservation (DOC) land, including wilding pines** • **Short forest or shrubland (with potential to reach ≥ 5 m at maturity in situ) on DOC land** • **Roads/tracks less than minimum width on DOC land, within the above 2 categories** • **Tall forest (≥ 30 % cover) on other (non-DOC) land** • **Broadleaved hardwood shrubland, manuka/kanuka shrubland and other woody shrubland (≥ 30 % cover, with potential to reach ≥ 5 m at maturity in situ) on other (non-DOC) land under current land management**
Pre-1990 Planted Forest	• Radiata pine, Douglas-fir, eucalypts, or other planted species as at 1990 (with potential to reach ≥ 5 m height at maturity in situ) • Harvested areas as at 1990 (assumes these will be replanted, as deforestation was extremely rare in 1990) • Roads/tracks/skids less than minimum area/width within forested areasRiparian or erosion control plantings (≥ 30 % cover, potentially ≥ 5 m in situ)
Post-1989 Forest (2008 only)	• These include forests which meet the forest parameters adopted by New Zealand for the Kyoto Protocol reporting and have either been planted or established after 1 January 1990 on to land which was non-forest land as at 31 December 1989. Generally these forests are planted with exotic species, but they may arise from natural regeneration of indigenous tree species as a result of management change after 1 January 1990 • For exotic forest they include Radiata pine, Douglas-fir, eucalypts, or other planted species (with potential to reach ≥ 5 m height at maturity in situ)Roads/tracks/skids less than minimum area/width within forested areas • Riparian or erosion control plantings (≥ 30 % cover, potentially ≥ 5 m in situ)
Grassland – with woody biomass	• Grassland with tall tree species (< 30 % cover), • Grassland with riparian or erosion control plantings (< 30 % cover) • Grassland with matagouri and sweet briar where it is expected that the forest criteria will not be met over a 30–40-year time period under current management • Grassland with broadleaved hardwood shrubland, manuka/kanuka shrubland and other woody shrubland (< 5 m and any % cover), which is expected to not meet the forest criteria over a 30–40-year time period under current management
Grassland – high producing	• Grassland with exotic species

Grassland – low producing	• Low fertility grassland on hill country • Tussock grasslands • Montane herbfields and above timberline shrubland vegetation (which does not have the potential to > 5 m height in situ) • Tussock grassland with linear shelterbelts • Other areas of limited vegetation cover and significant bare soil
Cropland – perennial	• All orchards and vineyards (it is assumed that no crops meet the forest definition) • Linear shelterbelts associated with cropland
Cropland – annual	• All annual crops • All cultivated bare ground • Linear shelterbelts associated with cropland
Wetland – open water	• Lakes, rivers
Wetlands	• Herbaceous and/or non-forest woody vegetation periodically flooded. Scattered patches of tall tree-like vegetation to be included as wetlands • Estuarine/tidal areas including mangroves
Settlements	• Built-up areas and impervious surfaces • Grassland within ‘settlements’ including recreational areas • All woody classes within ‘settlements’, including green-belts
Other	• Montane rock/scree • Largely bare ground (if not cropland) • Any other remaining land