FARMING FROM THE GROUND UP

THE USE OF LAND RESOURCE INFORMATION AS A BASIS FOR PLANNING FARM-SUSTAINABILITY IN NEW ZEALAND

VOLUME ONE

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the requirements for Doctor of Philosophy (Soil Science)

at Massey University, Palmerston North, New Zealand.

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ABSTRACT

Land resource (LR) information describes the character and capability of natural and physical resources as they vary across the landscape, while land evaluation is the decision-making process of assessing the fitness of land for a given purpose or use. This thesis argues and examines LR information and land evaluation as a fundamental prerequisite for the design and management of sustainable farming systems in New Zealand (NZ).

Sustainability may be defined as *the ability of one or many systems to sustain one or many systems over a period of time*, while conceptual applications can be clarified by stating the 'what', 'why', 'who', and 'for how long' of sustainability, and the hierarchical tier at which a given interpretation is applied.

Farm sustainability is achieved when all objectives, obligations, and requirements associated with a farm system are fulfilled in a reconciliatory way. Maintaining farm sustainability is dependent on the ability of management to adjust to change, particularly as it relates to refining or redesigning land use in a way that generates a profit without compromising land integrity and environmental quality. Ongoing soil, water and biodiversity problems linked with agriculture demonstrates that the reconciliation of farm sustainability is a difficult proposition. This difficulty will increase as the farming environment becomes more complex, dynamic, and demanding.

New Zealand's 16 regional authorities are responsible for ensuring the sustainable use and management of farmland. An examination of policy instruments confirms that the autonomy afforded under the Resource Management Act (RMA, 1991) has resulted in major differences in how each authority endeavours to fulfil these responsibilities. A non-regulatory emphasis prevails, and substantial assistance is currently available to most farmers interested in progressing the sustainable land management (SLM) dimension of farm sustainability. This situation may change within the next 10-15 years if the non-regulatory emphasis fails to adequately progress SLM.

Generating and using LR information through land evaluation represents a methodical and effective means of communicating, demonstrating, and planning farm sustainability. Farm-scale land evaluation provides a framework for identifying and systematically evaluating alternative land-use options in terms of potential economic performance and possible environmental impacts.

Farmers' apparent predisposition for informal decision-making means that most rely on their 'knowledge of the land' and informal methods of land-evaluation when making decisions concerning land-use and management. While informal methods are important, it is generally accepted that traditional approaches to farm management need to become more formal, strategic, knowledge intensive, and information rich, to better accommodate the modern challenges of sustainable agriculture.

A key constraint to the use of more-formal approaches to land evaluation is the availability of appropriate LR information. A critical evaluation of NZ's map collections and databases concludes that reliable and relevant LR information for farm management purposes cannot be obtained from existing sources. Most sources are unsuitable because of limited geographical coverage and inappropriate scales. Farmers interested in using LR information for farm management purposes can only do so if they collect new information.

A survey of NZ organisations and consultants who specialise in the collection and provision of LR information indicates that a wide variety of commercial survey services and resources are available. A complete exercise resulting in professional soil and paddock maps could cost up to $7000. The high cost of contracted LR-information collection can be reduced substantially through either having a regional authority 'farm plan' prepared, or through assisted soil survey programmes.

A detailed review of historical literature shows that regional authorities and their antecedent catchment boards have long recognised the value of farm-scale LR information and land evaluation for promoting wise and sustainable land use. This recognition is expressed as an evolving 'farm plan' model of land inventory survey, land capability classification, and integrative land-use planning for individual properties. A total of 4730 farm plans representing 50% of NZ's total farmland were prepared before NZ's reform of resource management in 1989. Most have a limited value as a contemporary source of LR information, but the traditional farm plan model is still generally suitable for modern-day land evaluation applications (albeit with refinements for modern issues).

Autonomy afforded under the RMA (1991) resulted in some regional authorities discontinuing the practice of farm planning, while others experimented with new or refined models to better accommodate the demands of sustainable resource management. An interview survey during 2001-2002 identified that approximately 1200-1450 *new* farm plans had been prepared between 1991 and 2001, and that farmers from eight of NZ's sixteen regions (or unitary districts) have access to some form of farm planning service.

A critical evaluation of contemporary farm plan examples shows that the independent development of farm planning during the 1990s has resulted in a diversity of at least 23 different farm plan models. Only five models involve the combined collection of farm-particular LR information, land evaluation, and integrative land-use planning. Farmers interested in obtaining new LR information through a contemporary farm plan can only do so if they reside in the Wellington, Manawatu-Wanganui, Hawkes Bay, or Taranaki Regions.

An alternative low-cost option for collecting, interpreting and using LR information to promote farm sustainability is through the fledgling Soils Underpinning Business Success programme (SUBS). A survey-based evaluation indicates that SUBS farmers attribute substantial land-use and management change to the programme, and are in strong agreement that participation has been beneficial to their abilities as farm managers and the sustainability of their farming operations. Further application of SUBS carries the potential for widespread improvement in farm sustainability, provided future applications are refined in terms of delivery, supporting material, and quality standards. Some headway has already been made, including the development of training and extension resources reported in this thesis.

NZ's presently underdeveloped state of LR information and use creates a large number of opportunities that carry an under-recognised potential for advancing both economic development and sustainable resource management. One option calls for a revised national survey involving the collection of a defined core of LR information at scales relevant to the level at which the majority of land-use decisions are made (*i.e.* farm scales), to be integrated with an active partnership programme to stimulate actual uptake and application from decision-makers themselves. Another borrows from an historical success, to suggest an intensive investment of science and technology into select farms as a means to focus and maximise capabilities towards the identification of solutions regarding persistent environmental problems. The ultimate aim being a new generation of farm plan that exploits our current understanding of biophysical processes and advances in spatial technologies.

The greatest single opportunity is for a national review to clarify the contemporary status and future direction of LR information and land evaluation in NZ. Resolving key review questions could underpin the establishment of a proposed national strategy, with an overriding purpose tightly focused on stimulating sustainable development and management from the proverbial 'ground up'.

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INTRODUCTION

BACKGROUND

Mankind has been assessing land for utilitarian purposes since the dawn of agriculture. Shifting forms of agriculture relied on identifying new fertile areas of land, possibly through a combination of observation-based reasoning, experimentation, and eventually experience (*e.g.* knowing which areas of land to return to year after year). Stationary forms of agriculture would allow a greater diversity of trial and error experimentation, with successful results being retained and built upon; transferred to other farmers by neighbourly example; and accumulating as local knowledge shared within and between generations.

One could expect that our methods of assessing land would have become quite sophisticated since these early times. Indeed they have, particularly with regard to scientific methods of collecting facts and data concerning land, and its formal interpretation or analysis for evaluating the impact and performance of alternative land uses. However, despite having these tools and methods available, many of those who retain the greatest individual responsibility in deciding how land is used, still rely on informal methods of land assessment similar to those first developed by our earliest agriculturalists.

This situation is apparent with New Zealand's pastoral agriculture. By necessity, NZ farmers are continually required to adjust and refine their systems of land use in response to changes largely beyond their control (*e.g.* climate, market fluctuations, legislation, changing needs and perceptions of society). Through such adjustments farmers endeavour to ensure their farms remain viable, ideally in a way that does not unduly compromise the productive integrity of land or the quality of the wider environment (farm sustainability). For a modern farming system, continually and effectively reconciling these often conflicting requirements is a sophisticated and complex task, which by default and preference, many farmers undertake without the benefit of land resource (LR) information and formal land evaluation methods.

Perhaps it is of little surprise that agriculture is frequently implicated with examples of environmental degradation, and is constantly threatened by market access restrictions and greater legal compliances relating to land use. Reliable LR information that is relevant to individual farms, coupled with structured land evaluation and related decision-making processes, provides a comparatively more robust, transparent and rational means of identifying and evaluating the positive and negative consequences of land use change.

THESIS

Land resource information is a fundamental prerequisite for the design and management of sustainable farming systems in New Zealand.

GENERAL HYPOTHESIS & AIMS

Land resource information can be used to promote farm sustainability if *appropriate information can be sourced and used by farmers in their decision-making and planning*. Sub-hypotheses have been generated and explored as individual chapters (each chapter essentially represents a standalone study with its own aim and objectives). General aims include:

1. Define farm sustainability.
2. Identify how farm sustainability is being promoted in New Zealand.
3. Describe the theory linking LR information to farm sustainability.
4. Qualify the appropriateness of existing LR information sources and services for promoting farm sustainability.
5. Evaluate historical and contemporary 'farm plans' as a collective source of appropriate LR information, and 'farm planning' as a comprehensive land evaluation framework for modern-day collection and use of LR information.
6. Evaluate the 'effectiveness' of the Soils Underpinning Business Success programme (SUBS) for promoting farm sustainability.
7. Design practical tools and resources for assisting farmers in the collection of new LR information.
8. Discuss future directions for a greater use of LR information in New Zealand farming.

STRUCTURAL OVERVIEW

This thesis is made up of nine chapters divided into two volumes. For the most part, each chapter accommodates one of the aims given above, except for Chapters 5 & 6 (which have been separated to distinguish historical and contemporary 'farm planning'). Chapters are presented with their own standalone structure (each includes a table of contents, introduction, etc.).

Chapter one

Sustainability is an agreeable but ambiguous concept, subject to problems of multiple interpretation and misappropriation. Chapter one discusses the concept's rise to popularity, and why its elusive definition continues to create confusion and disagreement between different sectors of society. System theory is used to identify and argue six criteria useful for clarifying specific applications of the concept. In turn, criteria and systems principles are combined to generate an interpretation of farm sustainability used throughout the remainder of this thesis.

Chapter two

NZ regional authorities are responsible for ensuring farmers manage their natural and physical resources in a sustainable way. Chapter two outlines NZ's resource management framework, and reports on a nationwide interview survey looking at how each of NZ's 16 regional authorities are promoting sustainable land management (SLM) within their own respective jurisdictions.

Chapter three

NZ farmers seem to exhibit an almost tenacious reluctance to the promotion of SLM and environmental management. Chapter three examines the role of information in farm management, and argues that LR information and formal approaches to land evaluation represent an effective option that allows pastoral farmers to satisfy their socio-economic necessities and land use prerogatives, while at the same time avoiding, mitigating or counteracting undesirable environmental impacts.

Chapter four

A considerable array of LR information exists in NZ, but it varies widely in terms of coverage, quality, and overall usefulness to farmers. Chapter four evaluates the relevance and reliability of NZ's existing sources of LR information according to predefined criteria (*e.g.* coverage, scale, quality, accessibility, etc.). In turn, a combination of research methods have been used to identify the types and costs of various survey tools, resources, and services available to farmers interested in obtaining new information. Results are used to construct 'best option scenarios' at different costs and qualities.

Chapter five

'Farm planning' undertaken by catchment boards and regional authorities represents a form of farm-scale land evaluation applied extensively throughout NZ since the early 1950s. Chapter five comprehensively explores the historical development of farm planning in NZ. It also examines farm plans as a potential source of detailed LR information, and the suitability of the traditional farm plan model for modern-day purposes.

Chapter six

Regional authorities received a high degree of autonomy in the late 1980s, allowing some to discontinue 'farm planning', and others to adapt the traditional model to the new requirements of sustainable resource management. Chapter six reports on a national survey that identifies the status and character of current farm planning, along with a second study that examines the wide diversity of modern-day farm plan models currently being applied. Chapters 5 & 6 represent NZ's most thorough account of historical and contemporary farm planning.

Chapter seven

The Soils Underpinning Business Success programme (SUBS) is a recent initiative that aims to train and assist farmers in the collection and use of soil information, ultimately towards the purpose of promoting farm sustainability. Chapter seven overviews the development of SUBS, and reports on a survey involving all farmers who had completed the programme as of August 2003. This includes an assessment of programme effectiveness in terms of original purpose, recognised benefits, outcomes, and ongoing farmer development. Suggestions for improving future applications are also provided.

Chapter eight

Chapter eight describes and presents versions of three resources originally designed to assist initiatives relating to farmers collecting & using their own LR information. Resources include: a low cost soil colour chart booklet (Munsell colours) designed for press-print output at a high standard suitable for in-the-field determination of soil colour; soil description laminates designed to simplify and speed-up the process of soil profile description; and a prototype training guide for the application of the SUBS programme.

Chapter nine

Chapter nine provides a summary of key findings, and a concluding discussion about future opportunities and constraints for a greater use of LR information and land evaluation in farm decision-making.

Chapter 1

THE CONCEPT OF SUSTAINABILITY

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INTRODUCTION

Sustainability is now widely accepted as a general principle that, in it's broadest sense, seeks to describe the relation between human development and the integrity of ecological and socio-ecological systems. The concept has been captured and ensconced in legislation, policy and formal agreements throughout the modern world, and it's popular usage across a broad range of disciplines reflects a degree of conceptual flexibility that agreeably accommodates diverse perspectives.

However, flexibility also lends the concept to misappropriation and multiple interpretation. The term can legitimately be applied to virtually any context or issue with a dimension of desired continuity, leaving it open to misuse by those who may benefit from the environmental morality and responsibility that the concept tends to convey.

New Zealand farmers must seek to ensure their farming systems are sustainable. This includes not only acknowledging the legal and ethical responsibilities associated with managing natural resources such as land, but it also includes having to continually adjust the farm system so that it may remain viable in an ever-changing world. Ensuring farm sustainability is a difficult challenge unto itself, which is not helped when the concept's flexibility and ambiguity generates ongoing confusion between farmers, interest groups, and policy makers.

This chapter begins with an historical background to the emergence and evolution of the sustainability concept, highlighting not only why the concept has become so popular, but also how underlying principles and themes have been evident throughout humankind's history. This leads into the chapter's main aim: to construct a conceptual framework through systems theory, useful for explaining why sustainability can be applied in such a wide range of contexts. The framework provides six criteria with value towards clarifying contextual applications of the concept. These criteria are then applied as an interpretation of farm sustainability.

Sustainability from a systems perspective is remarkably dynamic and complex, so there is good reason why such a large degree of confusion exists between farmers, interest groups and policy makers. Provided attempts are made to explicitly state what is meant by the term when applied to different farms, much of this confusion can be reduced.

ORIGINS OF THE SUSTAINABILITY CONCEPT

There is good reason why most texts on sustainability begin with an overview of the concept's history. Firstly, history allows us to view modern day problems within a context of accumulated experience and understanding. 'Knowledge of the past is an aid to interpretation of the future' (Thucydides, c. 470-400 BC), meaning we can learn from the past in our efforts to resolve today's sustainability related problems (Hillel, 1991).

Secondly, sustainability is about humankind's evolving relation with our socio-ecological environment (Gallopin & Raskin, 2002). This relation has been ongoing since time immemorial, with many of the themes and principles associated with sustainability being evident throughout history (Pepper, 1984; Reid, 1996; Harding, 1998; Bell & Morse, 1999; Oskamp, 2002). Hence, through historical review we gain not only an appreciation of the principles involved, but can also gain a contextual insight into how the sustainability concept has become so politically and publically popular today.

1.1. HISTORICAL THEMES AND PRINCIPLES

Exactly when mankind began to evolve as a species is unclear. However, at some stage in history, we must have existed wholly within the boundaries of the natural environment, as little more than an ecosystem component with no overt influence on the 'steady state' dynamics of the greater ecosystem. Today, similar states are often idealised as a form of ecological sustainability, whereby population numbers are regulated by competition and absolute resource scarcity, and human needs are mostly limited to *basic* and perhaps *fundamental* needs (Section 3.1.5).

This state began to change when humankind developed to alleviate some of the more pressing ecological limitations imposed by competition and resource scarcity. This was partially adaptation through technology, such as the development of tools and weapons that allowed our predecessors to extend and defend their ecological niches, thereby providing an improved degree of security and well-being conductive to population growth. Around one million years ago, this technical progress extended to pyrotechnology, which represented 'a momentous technical innovation' signifying 'the beginning manipulation of the earth's ecosystems' (Hillel, 1991, p.59).

Humankind existed primarily as nomadic hunter-gathers up until around 8000 years ago. In one sense, they were still relatively benign in their impacts on the greater ecosystem, although there is some evidence suggesting they contributed to the extinction of several large herbivores, and it is suspected that the use of fire resulted in large areas of heathlands and bogs in North-western Europe (Hillel, 1991). In another sense, humanity had become the dominant organism in many ecosystems, with their success measured in a rise of population to 10 million (Meadows *et al.*, 1992), with the leisure to develop social and cultural activities such as music, dancing, rituals, storytelling, rites of passage, and artistic creativity.

However, the prevailing hunter-gather way of life then sustaining human development began to reach a new ecological plateau of wildlife scarcity, necessitating a radical change in survival strategy (Hutchinson *et al.*, 1977; Meadows *et al.*, 1992). One segment intensified their migratory lifestyle, moving out of their ancestral homes of Africa and the Middle East to colonise new game-rich lands, while another segment did the opposite and settled in locations to domesticate animals and cultivate plants (Meadows *et al.*, 1992). The latter strategy represents a defining point in history known as the 'Agricultural Revolution' or the 'Agricultural Transformation'.

Semi-nomadic and stationary forms of agriculture were successful responses to wildlife scarcity as they provided a reliable food supply. Further, living in one place for an extended period was conducive to improved community stability, security, and development. Production surpluses introduced ideas of trade and monetary values; division of labour gave rise to trade specialisation; and ideas of individual ownership of primary resources began to arise. The success of agriculture and its flow-on social effects, eventually lead to urbanisation and the establishment of heavily populated and socially sophisticated centres of civilisation.

The Agricultural Revolution is marked as a period when humanity began to affect and control their natural environment to a greater degree than ever before. They actively selected and modified large tracts of land, clearing away natural flora and fauna to be replaced by preferred crops and livestock more attune to fulfilling their needs. The capacity of ecosystems to sustain a diversity of life was appropriated, modified, and managed, to better suit human purposes on a wide scale.

As a direct consequence, humanity entered more firmly into two of the central paradoxes of sustainability (as the concept relates to human activity). Firstly, because agriculture was such a successful strategy, it became the default response whenever ecological limits were approached. Overcoming limitations allows for increased well-being and population growth, up until a point where new ecological limits are reached. This again necessitates further appropriation/development/management as either agricultural expansion or intensification, which in turn results again in increased well-being and growth. Hence, humankind became dependent on a cycle of ever increasing ecosystem manipulation, in order to maintain human progress.

Secondly, ongoing anthropocentric appropriation/development/management of nature has invariably resulted in the decline of intrinsic ecosystem function, including reduced capacity to sustain natural diversity, and reduced or overloaded capacity to process and assimilate waste - both of which have reciprocally contributed to reduced ecosystem capacity to sustain human life, due to system exhaustion or pollution.

Ancient history is interspersed profusely with examples of social collapse arising from such degradation. Mesopotamia, Great Zimbabwe, the Central American Civilizations, Easter Island, The Cahokian Indians, Phoenicians, Greeks, Carthagenians, and Roman civilisations, have all had their demise in someway implicated partly or wholly with overpopulation, salinization, overgrazing, deforestation, soil erosion, siltation, or depletion and pollution of water resources (Hyams, 1952; Hillel, 1991; Jordan, 1995; Salamon *et al.*, 1998). Between ten and thirty civilisations are thought to have followed a pattern of demise through resource depletion and degradation (Blakeley, 1992), with the prosperity of many non-shifting agrarian societies being limited to an average of 300 years (Williams, 1993).

There were, however, a few societies that persisted better than others. In part, they developed a capacity to foresee the limits to their actions, and responded with conservation technologies, practices, and forward planning, which allowed them to conserve the productive integrity of agricultural land (at least for human purposes), thereby extending their periods of prosperity. As noted by Hillel (1991), judicious use and management of land and water at least maintained, and occasionally enhanced, the development of some societies in the Near East, parts of America, China and other parts of Southeast Asia, with the irrigation-based civilisation of Egypt being able to sustain itself for over five millennia.

These early forms of conservation represent the seeds of modern sustainability. While being wholly anthropocentric (i.e. conservation of land, water and other natural resources for their utility value), such actions reflected a philosophy of managing developed ecosystems in a way that did not irreparably despoil, exhaust or extinguish the ability or capacity of the biophysical environment to sustain human needs over-time. This is the essence of anthropocentric sustainability.

Ideas of conservation were also captured as indigenous beliefs and religion in early history. Indigenous beliefs, including those of less developed cultures that predate organised religion, are noted as sharing the same core idea of 'living in harmony' with nature (Mebratu, 1998). Such ideas were passed down by tradition, and reinforced through taboos and other forms of superstition based restrictions.

Likewise, organised Western religions also contain principles that can be interpreted as encouraging an harmonious relation with nature. As modern Christian environmentalists are quick to point out, the Judeo-Christian message portrays mankind with a stewardship role toward nature (Attifield, 1983; Doughty, 1981). However, much of their argument stems from the way in which the term 'dominion' is interpreted, as it appears in the first chapter of the Old Testament: '*and let them have dominion over... fish... fowl... cattle, and over all the earth*' (Genesis 1:26). From one perspective, 'dominion' can be interpreted as stewardship and responsibility, while from another it could mean ownership and domination (Jordan, 1995). Such ambiguity has lead some to conclude that organised religion has been neither an epitome of stewardship values, nor a free license for ecological subjugation; rather, it has been both (Gottleib, 1996; Mebratu, 1998).

The theme of conservation emerges again during the Middle Ages, but in a slightly different context (Jordan, 1995). Ideas of forest ownership can be traced back at least to the beginning of the Middle Ages, whereby the emerging segregated class structure of feudalism enabled the establishment of various laws to protect royal and manorial forests and woodlands. However, feudalism also encouraged widespread deforestation to make way for revenue-earning agriculture, necessary for supporting feudal lords and royal courts through tributes. As forests were cleared and land enclosure increased, the royalty and gentry reacted to conserve game and game-habitats as hunting reserves set aside expressly for sport. Such actions can be considered as conservation because the use of natural resources for human purposes was extended - albeit for the leisure purposes of an elite few. Widespread conservation for intrinsic or equality purposes didn't emerge until much later.

1.1.1 Principles and themes from the Industrial Age

Agricultural expansion and intensification, along with increasing social order, compounded over the centuries to allow the human population to grow to 800 million by the mid 1700s (Meadows *et al*, 1992). Another contributing factor was the popular rise of science around the 16th century, which had profound effects on the way in which limits to growth were overcome, and the way in which society viewed its relation with nature (Robinson, 2002). So called 'Baconian science' (after Francis Bacon, 1561-1626), the forerunner to modern science, placed emphasis on abstraction, reductionism, and 'the universal pursuit of permanent and timeless truths through the language of mathematics' (Robinson, 2002, p.40).

Science provided the means to assert increasing control over nature through technology, which came to the forefront during the British Industrial Revolution of the 1750s. Humanity 'finally mastered the forces of nature that had for so long dominated them' (Jordan, 1995, p.12) - or at least overcame some of the more persistent ecological limitations - through new energy sources (namely coal and steam), mechanisation, and production line specialisation; all of which functioned within a laissez-faire style capitalism. Agrarian reform soon followed, spurred in part by rural drift to population centres, and the emergence of labour-saving farm machinery. Over-time, the material wealth of nations capable of adopting technical innovations increased (leading to today's 'developed' nations), allowing population growth and urban expansion to accelerate at unprecedented levels.

Industrialisation marks a point where the juggernaut of human development really began to gain momentum. While this has certainly resulted in much improved well-being and lifestyle for industrialised nations, it also represents the beginning of an intense period of resource exploitation, degradation, and pollution. As noted by Robinson (2002), outcomes from industrialisation included 'large-scale modifications of the environment through extensive deforestation and substantial pollution related to industrial processes… and, later, industrial-style agriculture' (p.41). Initially this was on local and regional scales, but soon moved up to international scales as a result of overpopulation-induced colonisation, and the ever increasing need for exogenous primary resources to fuel empire building.

Three very important ideas emerged during the Industrial Age concerning wealth and society's relation with nature. Firstly, the capitalist pursuit of material wealth became a means for individuals to breakout of class structures, and paved the way for organised national economies and constitutional style governments. In 1776, Adam Smith (1723-1790) advocated that an organised economy should be based on private businesses functioning within a market regulated by supply and demand alone, both in a national and international context. Such unrestrained capitalism encouraged the pursuit of material wealth, and in the absence of any serious regulation, gave entrepreneurs free license to exploit nature and natural resources on a wide scale.

Secondly, a marked philosophical separation between society and nature became apparent, whereby science and technology placed people above nature, as it gave them increased power to control and manipulate it for utilitarian purposes. This human/nature dualism was strengthened as urbanisation increasingly dissociated more and more people from nature, alienating and insulating them from the realities experienced by those working the land (Jordan, 1995; Robinson, 2002). Further, Charles Darwin (1809-1889) inadvertently fuelled the conceptual divide, by placing humankind at the top of the evolutionary pyramid in his widely influential *Origin of Species* (Darwin, 1859). This gave rise to social Darwinists with their self-ascribed right to dominate lesser life forms, and 'supreme confidence in their racial superiority' over indigenous peoples during colonisation (Hayward & McChesney, 1992, p.36).

Capitalism, utilitarianism and the human/nature dualism became firmly entrenched in the human development paradigm, to be applied as a means to overcome the seemingly more and more less restrictive ecological limits imposed by nature. Further, they were also applied to overcome new socio-ecological limitations, inadvertently self-imposed through both the manipulation of natural systems, and the increasing complexity of industrialised society. In a sense, the big solution of industrialisation began to become the big problem.

The third idea that emerged during the Industrial Age represents an early backlash against industrialisation itself. This was first encapsulated as Romanticism beginning in the late 1700s, which 'deplored the scientific and technological forces… regarded as dehumanising man and degrading nature… hated industrialisation for making the beautiful ugly… and rejected the vulgarity of those who made money in trade' (Jordan, 1995, p.12). In short, it was anti-science, anti-rational, and anti-technocratic, desiring aesthetic over utilitarian values, and advocating a romanticised version of rural life known as 'Arcadia' (Robinson, 2002). This utopia involved a return to the perceived harmony between man and nature, similar to some of the alternative rural-based lifestyle models of the twentieth century.

Romanticism contributed significantly to thinking about the human/nature relation. It went beyond ideas of practical conservation of nature and natural resources for future utility, to introduce the ideal that nature should be protected for its intrinsic value (nature for nature's sake). Nature had integrity 'beyond the sum of its parts', and therefore value beyond use for generating material wealth. In a sense, the romantics were the first environmentalists, or 'idealistic conservationalists' (Jordan, 1995), as they idealised the intrinsic value of preserving or conserving nature above its utility value.

Another early reaction against the impacts of industrialism was provided by Thomas Malthus (1766-1834). He expressed concern that the upsurge in population growth would exceed predicted limits of food production, theorising that people increase in number at a geometric rate (exponentially), but food production can only increase arithmetically at a linear rate. While his predictions were flawed through omission of food production increases gained through science and technology, he is regarded as the first economist to foresee limits to growth caused by resource scarcity (Mebratu, 1998). Similarly, but in a completely different context and discipline, Justus von Liebig (1803-1873) noted that plant growth is controlled by the factor that is present in the most limiting quantity, up until the point where another factor becomes most limiting. This principle eventually lead to agriculture's widespread use of inorganic fertilisers, and thus contributed to the increased food production that negated the 'limits to growth' theory of Malthus.

Although longer in coming, early naturalist writers and botanists of the 19th century also expressed reaction against industrialism. Initially, this reaction appears to be utilitarian in perspective, such as Alexander von Humbolt's (1769-1859) practical concerns relating to deforestation and natural resource exploitation in South America, but gradually becomes more ecocentrically orientated towards the end of the century. Charles Darwin made reference to von Humbolt's concerns in 1845, but also recognised the intrinsic value of South America's unique ecosystems irrespective of their utility value. Henry Thoreau (1817-1862) put forward a similar view, rejecting the 'conquer and extinguish' pioneering approach being applied to the North American wilderness in the mid-1800s. Thoreau was supported by George Perkins Marsh (1801-1882), who's book *Man and Nature* (Marsh, 1864) had a 'tremendous influence on succeeding generations of conservationists and ecologists' (Jordan, 1995, p.14), leading some to dub him as the 'first global environmentalist' (MacLean, 1995). John Muir (1839-1914) followed Marsh, widely publicising the environmental degradation of late 1800s California, and founding one of the first organised environmental groups known as the Sierra Club.

1.1.2 The Conservation Movement

Naturalists like Marsh and Muir contributed to the emergence of national protection policies for large tracts of North American wilderness, such as Yellowstone National Park in 1872. However, the backlash against industrialisation and subjugation of nature didn't gain serious public and political traction until the rise of the Progressive Conservation Movement of the 1890s and early 1900s (Pinkett, 1970; Graham, 1971; Batie, 1989; Jordan, 1995). While beginning in America and focusing almost solely on wilderness protection, it didn't take long for the Movement to expand into agriculture and across into other industrialised nations.

Theodore Roosevelt (1858-1919) perhaps best captured the conservation philosophy of the Movement in his first State of the Union Message soon after becoming president in 1901. He spoke of forestry as a national renewable resource, whereby 'forest protection… is a means to increase and sustain the resources of our country and the industries which depend upon them', perceiving forestry conservation as 'an imperative business necessity'. Further, he stated: 'whatever destroys the forest, except to make way for agriculture, threatens our well-being' (as cited in Graham, 1971, p.105; and Jordan, 1995, p.15).

An important idea was clear in his statement. Not only did he use the term sustain, but he coined it in a dual context of society sustaining the forestry resource, so that the resource may be in-turn used to sustain continued industrial and business growth. In effect, he was talking about *sustaining the ability to sustain*, which is often the most confusing and difficult idea to grasp in the whole sustainability debate. A systems perspective is used to explain this in Section 1.3.

Roosevelt's interpretation of conservation was wholly utilitarian and practical in character, which is a well noted feature common to many views expressed by the Movement's protagonists and supporters (Batie, 1989; Nash, 1989). They focused on the practical means to use nature without destroying it, which was distilled into the words of *wise-use* to become the guiding principle of natural resource conservation for the greater part of the 20th century (Jordan, 1995). Hence, the emergence of the Movement marks a point where the meaning of conservation retreated from the strongly ecocentric and preservationist ideas of Marsh and Muir, and swung back into the practicality of protecting nature and natural resources for their utility value (Robinson, 2002).

The leading *wise-use* advocate and intellectual figurehead of the Movement's philosophies was Gifford Pinchot (1865-1946) the first chief of the US Forest Service. Pinchot repeatedly asserted that conservation did not necessarily equate to the preservation of nature (Nash, 1989). Rather, the concept meant 'technically efficient resource development' (Jordan, 1995), guided by ideas of 'multiple land use' and management according to scientific principles (Robinson, 2002). Such views lead to the Movement's underlying philosophy being termed 'The Gospel of Efficiency' (Hays, 1987), while forestry regulations that 'locked up the land' were dubbed Pinchotism – a depreciation akin to socialism or even communism (Jordan, 1995).

The American forestry conservation focus of the early 1900s shifted to agriculture and the 'soil conservation movement' in the late 1920s and early 1930s (see Chapter 7) in response to increasing concerns and evidence of land degradation through soil erosion. Of particular note is the Mid-West Dust Bowl of the early 1930s, during which drought and high winds combined to carry away great depths of unprotected soil from millions of hectares of farmland. Land became un-farmable, infrastructure was destroyed or buried, and farmers abandoned their land and drifted to cities already under pressure from the Great Depression. Public outcry and economic pressure lead to swift government response, establishing the Federal Soil Erosion Service in 1933 under the leadership of H.H. Bennett.

Early soil conservation efforts were strongly aligned with Pinchot's *wise-use* philosophy, perhaps best captured as Bennett's guiding dictum that 'each acre must be used according to its capabilities and treated according to its needs' (paraphrased by McCaskill, 1973, p.188). The idea of conservation farming arose (Hockensmith & Steele, 1943), which sought to apply the most efficient production system within the inherent and modified capabilities of land. The Service's efforts lead to widespread assessment of land in a context of its suitability to sustain productive uses (both in the US and other countries), and the integration of soil conservation ideals and practices into day-to-day agriculture through Conservation Farm Plans (Chapter 7).

The dominant views driving conservation shifted again in the mid-1900s. As noted by Batie (1989), World War II provides an approximate dividing line between the 'old' and 'new' conservation paradigms, whereby the emphasis increasingly shifted away from Pinchot's 'technically efficient resource development', and more toward aesthetic and amenity uses of natural resources associated with a rapid growth in outdoor recreation in the 1950s. Nature was still 'useful' in a production sense, but also increasingly useful in a non-productive sense. While this subtle variation supports protection of nature for human benefit, the outcomes are mostly intangible and align very closely to those pursued by ecocentric idealists. Hence, there can be a very fine line between conservation for the intangible utility of nature, and protection of nature for its intrinsic and non-human function.

The latter 'nature for nature's sake' view also reasserted itself in the mid-1900s. In 1949 a forestry manager by the name of Aldo Leopold published his provocative and influential *A Sand County Almanac* (Leopold, 1949), expressing concern over the Forest Service's liberal and somewhat inconsequential policies regarding logging and grazing privileges. This essay is regarded as the first attempt in modern Western literature to develop an ethical theory concerning the human/nature relation (Jordan, 1995), as it asserts that society has an ethical responsibility toward the protection of nature irrespective of its utility value. Leopold advocated a strongly ecocentric 'Land Ethic', in which 'a thing is right when it tends to preserve the integrity, stability, and beauty of the biotic community. It is wrong when it tends otherwise' (Leopold, 1949, p.224).

1.1.3 THE ENVIRONMENTAL MOVEMENT

Questioning of humankind's responsibility toward nature gained new momentum and direction in the 1960s and 1970s as the environmental movement. While increasing material flows through growing post-war economies revived questions about continued quantities of resources (Reid, 1996), it was concern for the quality of the natural environment (and resources) that gave rise to the first wave of environmentalism (Kidd, 1992). However, the environmental movement was much more than the 'deep green' environmental extremism that it has often been associated with. Rather, it was more a counter-culture movement characterised by the emergence of a large number of diverse and competing views regarding the human/nature relation. Events and literature characterising such views have been well documented (e.g. Kidd, 1992; Jordan, 1995; Mebratu, 1998; Robinson, 2002), and for the sake of brevity, have been summarised as a timeline in Appendix I.

The initial rise of the environmental movement is often traced to the release of *Silent Spring* in 1962 by Rachael Carson. This publication relates post-war America's thereunto unchallenged use and reliance on synthetic pesticides, and production of industrial wastes, to widespread decimation of wildlife and pollution of natural resource. It has been described as a 'landmark book' that dramatically brought the emerging problems of intensification and industrialisation to the public's attention (Jordan, 1995), unleashing a floodtide of debate and writing, 'which swiftly extended beyond the issue of pesticides to the whole question of what mankind was doing to the natural environment' (Brenton, 1994, p.19). Further, it stimulated widespread investigation into environmental impacts, and legislation to prohibit the most hazardous pesticides (Jordan, 1995).

Pollution and contamination was a dominant theme throughout the 1960s. Eutrophication and contamination of North America's Great Lakes was highlighted; acid rain in parts of Europe was implicated with air pollution; concerns of fallout from atomic testing arose; the Torrey Canyon oil spill brought marine pollution to the fore; and industry and agriculture were increasingly implicated and targeted as the leading causes of the pollution problem.

The issue of pollution brought together the two dominant views on the human/nature relation. From an ecocentric perspective, the industrial and agricultural pursuit of progress was killing-off wildlife and 'poisoning nature' on a wide scale. Anthropocentrically, public safety was threatened with the contamination of recreational resources (e.g. the US and Canada's Great Lakes), drinking water resources (e.g. the Love Canal incident), and food safety concerns from continued pesticide use. Hence, both pragmatist and ideological viewpoints came to the fore at the same time, contributing to widespread public reaction and support that was eventually translated into significant political action and environmental legislation towards the end of the 1960s (Brenton; 1994; Beder, 1996).

Another contributing factor relates to a growing awareness that the human/nature relation was of global concern. This was lead by the rise of globalisation in the 1960s, through which expanding communications, global economic interdependence, and transboundary pollution contributed to 'increased public awareness of events outside one's own national frontiers' (Brenton, 1994, p.23). The first pictures of earth from space gave a perspective of a finite global boundary (and therefore a finite capacity), supporting emerging views of global ecosystems, the 'ecosphere', 'spaceship earth', and the 'fragile planet'. The looming danger of worldwide nuclear war also had an impact, threatening the continued survival and security of humankind as a species, and highlighting that modern day limitations and hazards were increasingly social and self-created (*cf.* ecological or natural limitations).

The environmental movement's coming of age is marked by *Earth Day* in 1970, which involved the participation of over 20 million people, and provoked *Time* magazine to refer to 'the environment' as the issue of the year (Brenton, 1994). However, the early 1970s also marks the rise of a slightly different strain of environmental thought, whereby existing patterns of consumption, demographics, and pollution were extrapolated into the future to produce a series of 'doomsday' forecasts reminiscent of Malthus's limits to growth.

The first was Paul Ehrlich's *The Population Bomb*, which discussed trends in population growth leading to a substantial increase in the world death rate, and modelled world population 900 years thence at 60 million billion (Ehrlich, 1968). *Blueprint for Survival* (Goldsmith, 1972) followed four years later as an article in *The Ecologist* magazine, forecasting impending social collapse and irreversible decline in ecological life-support if pollution and consumption patterns continued. In the same year, *Limits to Growth* (Meadows *et al.*, 1972) was published, which reported on the use of a computer model to extrapolate the continued growth of five interconnected global trends (industrialisation, population, malnutrition, resource depletion, and ecological degradation). The conclusion that received the greatest attention (inset) predicted that 'if the present growth trends… continued unchanged, the limits to growth on this planet would be reached within the next 100 years' (*ibid.* p.23).

A COMPUTER LOOKS AHEAD AND SHUDDERS. STUDY SEES DISASTER BY YEAR 2100. SCIENTISTS WARN OF GLOBAL CATASTROPHE.

Newspaper headlines in reaction to Limits to Growth (from Meadows et al., 1992, p.viii)

These three publications became bestsellers and provoked intense debate about the future human/nature relation. The principle theme – that unchanged patterns of living and development would lead to global disaster – was another point of agreement between the polarised views of pragmatic conservationists and idealistic conservationists. However, while the character of the problem may have been agreed upon, forthcoming solutions and development philosophies were widely diverse and critically contested.

Two of the more alternative development philosophies were encapsulated in *The shallow and the deep, long-range ecology movement* (Naess, 1973) and *Small is beautiful* (Schumacher, 1973). The deep ecology movement is the more strongly ecocentric of the two, and is distinguished by rejecting the human/nature relation as a dualism – that people are a component part of nature and not separate from it. It recognises the intrinsic value of nature, and advocates that humanity's relation with nature should be guided by ideas of bioethics and biocentric equality (i.e. humans have no more right to exploit other species than those other species have to exploit humans).

Deep ecology promotes a paradigm shift from anthropocentrism to ecocentrism as the means for future progress, under the guiding philosophy of 'ecosophy' (literally 'eco-wisdom') at the level of individuals. In other words, individuals must evolve their attitudes toward nature to be more ecocentric, which collectively will bring about wide-scale change in social and economic systems. Today, the deep ecology movement is often associated with 'deep' or 'radical' greens, the green movement, and strongly ecocentric environmentalists.

An offshoot from deep ecology is the Gaia hypothesis (Lovelock, 1979), which considers all life on earth as being part of a single self-regulating super-organism. While it does not necessarily advocate it's own development philosophy, it promotes the ecocentric view of the human/nature relation on a scale well beyond deep ecology. In short, Gaia demotes humankind to a component of a living entity that is bigger, more ancient, and more complex than anything yet conceived (Miller, 1989). Credibility for such a radical perspective is difficult to convey in one short paragraph. However, Gaia puts forth a number of startling insights that have been widely debated, criticised, and endorsed in academic circles, and the underlying philosophy has given rise to its own culture of followers and protagonists ('gaianists').

A less ecocentric development philosophy is captured in *Small is beautiful* (Schumacher, 1973), which recognises the human/nature dualism as being inherent to industrialisation, and relates it to a flawed paradigm in which Western society believes it has solved 'the problem of production'. Schumacher uses common sense economics to convincingly highlight this as a misconception, and sharply criticises 'over-organised systems' and traditional economic models as being socially and environmentally destructive. In its place he proposes a decentralised system of intermediate and appropriate technology, based on smaller working units, cooperative ownership, and regional workplaces using local labour and resources. Economics is considered with an emphasis on people rather than the product.

The development philosophy behind *Small is beautiful* became an integral part of the 1970s counter culture movement. The phrase became a 'rallying cry' during public demonstrations, and gave 'a new impetus to a whole generation of environmental defenders' (Mebratu, 1998, p.500). It is also regarded as being seminal towards the development of later trends in community self-sufficiency and back-to-basics thinking (CEDC, 2002). Further, the term 'appropriate technology' (technology that takes heed of the skill, levels of population, and availability of natural resources) was accepted widely as a guiding principle for both developed and less-developed countries, leading some to consider it as the precursor to sustainable development (Mebratu, 1998).

1.2. EMERGENCE AND RISE OF THE SUSTAINABILITY CONCEPT

The environmental movement of the 1960s and 1970s is marked as a time when many alternative human/nature views were recognised. As noted by Kidd (1992), this represents part of an ongoing search for a set of ideas about humankind's long-range future. In this search, concepts emerge, become prominent or even dominant for a time, but then fall into disfavour through misuse, changed meaning, or the emergence of a more popular alternative. Some recent examples include Pinchot's *wise-use*, Schumacher's *appropriate technology*, and Sach's *ecodevelopment* (as discussed in Kidd, 1992). These and other 'sets of ideas' have gradually converged over the past several decades, and have come together as the overarching and somewhat unifying concept of sustainability.

Origins of the term itself have been traced to late Middle Ages Germany, when the principle of *Nachhaltigkeit* was used to describe renewable resource-management of forests. This word was initially translated to English as 'sustainable yield', and then later as just 'sustainability' (Held, 2000 as discussed in Schmuch & Schultz, 2002). Later in history, the phrase 'to sustain' was used with increasing frequency in the literature of the Conservation Movement (including the soil conservation movement), usually to refer to levels of production that could guarantee the maximum perpetual supply of food and fibre.

Sustainability as an explicitly standalone term and concept appears to be an emergent property of the 1970s. Firstly, it appears in *Blueprint for Survival* (Goldsmith, 1972) to describe the 'industrial way of life' and its associated 'ethos of expansion' as being unsustainable, and to highlight a 'sustainable society' as being humankind's ideal development goal. Around the same time, the IUCN made reference to managing environmental resources to achieve 'the highest sustainable quality of human life' (as cited in Kidd, 1992, p.13). Two years later, it appears in an international document as 'self sustainable development' (Sachs, 1994 as discussed in Jimenez-Doinguez, 2002), and in 1976 the Magnuson Fishery Conservation and Management Act (1976) became the first legal statute to enshrine the term in law, using it to describe 'maximum sustainable yields' of fishery stocks (Kidd, 1992).

However, recognition and support of the concept didn't gain any serious momentum until the United Nations used it to describe the future development of poorer countries, and then later as 'sustainable development' in an attempt to reconcile the widely divergent development issues apparent between industrialised and non-industrialised nations. These themes came to prominence through growing global awareness about environmental and development problems, emerging onto the world stage during the 1972 UN Conference on the Human Environment.

Also known as the Stockholm Conference, this event is recognised as the first major attempt to bring the international community together to address environmental concerns (Brenton, 1994). While not being the first, the Conference was one of the largest yet held: over 1200 delegates from 119 nations were involved; more than 400 representatives from non-governmental organisations attended; and over 1000 journalists contributed to widespread media coverage. The Conference's intent was to develop a concerted and constructive international response to the growing problem of environmental degradation and it's relation to continued human development.

Few effective formal outcomes emerged from the Conference, but informally there were many (*ibid.*). One of the more important highlighted 'quality of life' inequalities between various nations, expressed as divergent views regarding future global development. On the one side, wealthy industrialised nations were concerned mostly about pollution and industrial resources, and how they relate to continued development of affluent lifestyles and high standards of living. On the other side, poorer developing nations were more concerned with issues of poverty and the supply of basic primary resources, necessary for at least attaining a minimum accepted standard of living. In short, industrialisation was the problem for developed nations, but undeveloped nations saw it as the solution. This disparity was succinctly captured during the Conference when the Ivory Coast delegate commented that his country would welcome more pollution problems provided they were evidence of industrialisation (*ibid*).

While the phrase 'sustainable development' was not officially used during the Conference, the underlying idea was certainly present (Reid, 1995). The phrase itself was not forthcoming in an official international context until 1978, when sustainable development was interpreted in a little-known UN document to mean that 'the needs of present and future generations must be appropriately reconciled' (as cited in Kidd, 1992). This added a new dimension to the debate as intra- and inter-generational equity, which is a theme that both developed and less-developed nations would eventually come to agree upon. It also indicates a shift away from 'sustainable resource use' contexts, and into a new conceptual arena of social equity.

The concept of sustainability may have emerged during the 1970s, but it didn't gain widespread popular recognition until the early 1980s (Harding, 1998). Some regard this period as the beginnings of the 'second wave of environmentalism' (Beder, 1996); the second boom in popular environmental alarm (Brenton, 1994); the 'sustainability phase' (Newby, 1991); and the beginning of 'the sustainability revolution' (Williams, 1993; McKenzie-Mohr, 2002). Popularity grew as the concept moved out of the confines of technical articles, reports, and books with limited circulation, and into mainstream society as a guiding principle underpinning legislation, development planning, and many international agreements (Kidd, 1992).

The World Conservation Strategy (IUCN, 1980) is regarded as the document through which sustainability and sustainable development initially gained widespread publicity (Reid, 1996). This publication describes development as the modification of the biosphere for anthropocentric purposes (Section 1.3), and recognises such modifications are a threat unless guided by the principle of conservation. Conservation was defined as 'the management of human use of the biosphere so that it may yield the greatest sustainable benefit to present generations while maintaining its potential to meet the needs and aspirations of future generations' (Section 1.4). The Strategy closes with a section entitled *Towards Sustainable Development*, in which conservation and development are seen to be mutually dependent.

Popularity of the sustainability concept continued to grow throughout the 1980's, driven in part by a series of international ecological disasters (Appendix I) that were collectively responsible for a resurgence in public environmental interest (Brenton, 1994). However, it wasn't until the release of *Our Common Future* (WECD, 1987) that the concept 'politically came of age', and was distilled into a conceptual framework that guided the content and structure of the human development debate through the 1990s (Kirkby *et al.*, 1995; Mebratu, 1998).

1.2.1 OUR COMMON FUTURE

Also known as the Brundtland Report, this publication represents three years of high-calibre investigation into 'all aspects of the relationship between the environment and development' (Kidd, 1992, p.21). It was hailed 'as the most radical document to come out of a grouping consisting of the world's elite' (Ekins, 1992, p.viii), as it persuasively argues for 'sustainable development' as the central means to inclusively guide international human development, environment improvement, and alleviation of social inequities. Use of phrase has been described as 'genius' because it effectively bridged the gap between those arguing for economic growth, and those more concerned with environmental protection (Brenton, 1994). 'In one neat formula', sustainable development provided a slogan that both developed and developing nations could unite behind (*ibid.*).

'DEVELOPMENT THAT MEETS THE NEEDS OF THE PRESENT WITHOUT COMPROMISING THE ABILITY OF FUTURE GENERATIONS TO MEET THEIR OWN NEEDS'

The most widely used definition of sustainable development, initially put forward in the Brundtland Report (WECD, 1987, p.43)

However, while being very agreeable, the way in which sustainable development was defined (inset) hides a number of complexities inherent to the sustainability concept. Firstly, the term 'needs' can be interpreted in a number of different ways, which adds a high degree of confusion in the pursuit of intra-generational equity. Needs can be interpreted as the somewhat mechanical *basic needs* of food and fibre, clean water, fresh air, and shelter (Molloy, 1980); the broader *essential needs* of livelihood, food, energy, housing, water supply, sanitation and health care (WECD, 1987); the emotionally orientated *fundamental needs* of subsistence, protection, affection, understanding, participation, idleness, creation, identity, freedom, and transcendence (Max-Neef, 1991); and *affluent needs* necessary for the continued function of industrialised modern-day society (e.g. transport, communications, computers, etc.). Hence, what constitutes 'needs' can be widely divergent between different cultures and countries, and further, can actually change over-time as an ever-evolving expression of human development.

Secondly, the idea of inter-generational equity presupposes that present patterns of development will disadvantage future generations as they pursue their own levels of well-being and progress. However, history has repeatedly shown that these kinds of self-imposed socio-ecological limitations have successfully been overcome through the development of science and technology. Given the current high rates of technological innovation, many believe that any forecasted environmental or development problems should be the responsibility of future generations, as they will be better equipped to deal with them. Although this may ultimately lead to complete anthropocentric management of nature and natural resources (cf. nature managing itself), it appears to be the prevailing development path that humankind is currently progressing along (inset).

Thirdly, the WECD's definition of sustainable development is wholly anthropocentric in character. Considered alone, the definition encourages efforts toward social intra- and inter-generational equity, but fails to include the idea of biocentric equality. While the full Report recognises the value of ecological function and mentions the intrinsic quality of nature, the all-important definition conveys no implication whatsoever that ecosystems and their non-human components have a right to exist and function irrespective of their value to human development.

'WE ARE AS GODS, AND MIGHT AS WELL GET GOOD AT IT'

Reference to humankind's increasing understanding and ability to manage and control nature. From 'The Whole Earth Catalogue', as cited in Brenton, 1994, p.237.

Fourthly and lastly, the phrase 'sustainable development' brings together two often contradictory concepts, leading some to label it as an oxymoron (Jordan, 1995). In brief, sustainability can be taken to mean 'going on forever' (*ibid.*) or 'going continuously' (Vucetich, 1990), which contrasts against the sequential beginning, adolescence, maturity, and senescence of development processes (e.g. ecological succession, the rise and fall of ancient civilisations). As such, the phrase can be considered oxymoronic because development has temporal limits while sustainability apparently does not. However, as discussed in Section 1.4, this is not necessarily true when the sustainability concept is applied at different temporal scales.

1.2.2 THE FIRST EARTH SUMMIT

Despite these inconsistencies, the concept of sustainable development continued to increase in popularity throughout the late 1980s and early 1990s. It became the 'watchword for international aid agencies, the jargon of development planners, the theme of conferences and learned papers, and the slogan of developmental and environmental activists' (Lele, 1991, cited in Bell & Morse, 1999, p.3). Furthermore, sustainability's increasing popularity in the international arena eventually lead to it being conveyed from top tier decision-making, down to permeate through everyday society.

Widespread dissemination down to the grassroots level occurred during build-up to the United Nations Conference on Environment and Development (the first Earth Summit) held in Rio de Janeiro, 1992 (Mebratu, 1998). This preparatory process began in 1989 as a Resolution passed by the UN General Assembly in response to a recommendation put forth in the Brundtland Report (Reid, 1995). Literally several million people were involved in the process, either working on organisation of the event, the creation of broader public awareness, or working on specific substantive issues (von Weizsacker, 1994). These efforts 'took the concept of sustainable development to every corner of the world', as the process involved participation and input of stakeholders right down to the proletarian level (Mebratu, 1998, p.502).

The Rio Conference itself, like it's Stockholm predecessor 20 years before, was remarkable in it's attendance – 100 heads of state; 78 delegates from other nations; 1,500 representatives from 500 non-governmental organisations; and over 8000 journalists took part. It ran for eleven days, during which problems were aired, grievances were put forward, and the means to achieve sustainable development was critically debated. At it's close, five important 'Earth Summit Agreements' had been signed by the majority of attending nations, including: *The Climate Convention* as a framework for dealing with global warming; *The Biodiversity Convention* to protect sovereign rights regarding 'biological resources' for biotechnology, and to manage and conserve biodiversity itself; *The Forest Principles* as a non-binding statement regarding the conservation of the world's forests; *The Rio Declaration* as an 'earth charter' setting out the basic principles required to progress toward sustainability; and *Agenda 21*.

Agenda 21 was perhaps the most significant, as it represents the international community's 'action plan' toward achieving sustainable development. This is a massive document (40 chapters and 500 pages), which focuses on socio-economic development, sustainable resource management, strengthening the role of stakeholder groups, and the means through which propositions were to be implemented. It has been described as 'the most ambitious attempt yet to specify what actions will be needed to reconcile development with environmental concerns', and the key intergovernmental guiding and reference document for international development over the succeeding decade (as discussed by Reid, 1995, p.186). However, the effectiveness of *Agenda 21* has been limited in being non-binding and overtly comprehensive in the issues covered, leading Brenton (1994) to state that it has become 'a sort of vast and un-constraining menu from which countries [can] pick and choose actions and emphases according to their own priorities' (p.213).

1.2.3 Post Rio

Since the Rio Conference, the concept of sustainability has become consolidated as the centrally debated theme relating to the present and future human/nature relation. However, it also appears to have been gradually receding from it's publicity peak in the early 1990s, due in part to the compounding factors of failed implementation, fluctuating public environmental interest, and the seemingly wanton linking of sustainability to virtually any issue or context that could benefit from the environmental morality it tends to convey.

Failure to translate the ideals and agreements of the Rio Conference into meaningful on-the-ground action was highlighted at the next Earth Summit held in New York, 1997 (after Bissett, 1997 and Harding, 1998). The purpose of this Summit was expressly to gauge progress since Rio, with around 166 heads of state and delegates making the effort to report back on their advancement towards sustainable development. While considerable steps had been taken with environment policy, legislation, and establishment of ministerial organisations, the degree to which these upper-level initiatives were resulting in actual meaningful change was dubious. As noted by Smith (2002), although sustainability has been 'enthusiastically embraced by governments, individuals, and industry', it has 'proven hard to move from concept to action' (p.25). Many nations simply 'threw in the towel', and outright reneged on the environmental promises they had made five years earlier. This lack of progress resulted in some media dubbing the second Summit as being a failure (Bissett, 1997).

Similar headlines were also used to describe outcomes of the third Earth Summit recently held in Johannesburg, 2002. A shift away from 'sustainable development' to just 'development' was a noted theme (Bosselmann, 2002), particularly with America and Australia who were 'widely condemned for their destructive role during the Summit process' (Towle, 2002, p.8). US President Bush did not attend, which was taken as a symbolic indicator that sustainability was no longer important in world politics (Bosselmann, 2002). The conference was accused of selling-out 'to the WTO and big business' (*ibid.*, p.8), with environmental groups calling it a 'triumph of greed and self-interest, a tragedy for the poor and the environment' (Greenpeace, 2002).

The second factor of interest contributing to sustainability's decreasing public popularity involves society's fluctuating interest in environmental issues. Brenton (1994) links this to the 'issue/attention cycle' used in sociology, in which an issue will initially capture public attention, gradually rise as a social concern to 'a crescendo of public alarm', and then it will deflate as the cost and difficulty of remedial action becomes apparent.

Eventually 'public interest moves elsewhere often leaving the original problem unresolved, and the public as indifferent to it, as before the cycle began' (p.24). This is apparent with the environmental movement growing rapidly in the 1960s, peaking in the early 1970s, and then declining towards the 1980s. This decline is mirrored with a rise in substitute concerns regarding the oil shocks, the threat of nuclear war, and an economic downturn at the start of the 1970s.

A similar pattern can be attached to the popular rise of sustainability. The concept emerged during the 1970s and 1980s, built-up to it's peak at Rio in the early 1990s, and then has gradually faded as realities of implementation have proven to be too costly or difficult. Today, the concept's popularity is perhaps at it's lowest, compounded by the substitute concern of terrorism sparked off by the September 11th attack on the World Trade Centre.

However, the 1990s peaking of sustainability high on the international agenda resulted in the concept being consolidated into policies, legislation and agreements not easily implemented. Furthermore, persistent concerns that come around in cycles tend to build upon previous progress, rather than reverting to the low base of public attention from which they originally started (*ibid.*). And finally, different nations with their own particular environmental issues and ethics, will ascribe different levels of priority to the pursuit of sustainability and sustainable development (e.g. Australia *cf.* New Zealand on the issue of climate change). Hence, unlike the demise of previous concepts, sustainability will probably persist into the foreseeable future (Kidd, 1992; O'Riordan, 1993), and perhaps even resurge back into the centre of popular public attention with the next major wave of environmental concern.

The final compounding factor of interest has influenced the popularity of sustainability by undermining it's credibility. While the concept initially emerged in contexts of resource use and human development, it was soon linked with a wide range of sub-contexts that could claim a dimension of desired continuality or protection. This is due to the ambiguous character of the concept, which while contributing to it's popularity, also creates considerable disagreement over meaningful definition, thusly exposing it to misappropriation 'by those wishing to cloak "unsustainable" activity in [sustainability's] respectable garb' (Reid, 1996, p.xvii).

1.2.4 POPULARITY, AMBIGUITY AND MISUSE

Today, sustainability has become the catch-all term for the study of environmental issues (Schmuck & Schultz, 2002), leading some to label it as one of society's prominent 'buzzwords' and 'catch-phrases' (Reid, 1996), and in some cases elevating it to the prominence of a mantra or shibboleth (Mebratu, 1998). It has been consolidated in government policies, strategies, and legislation, and is increasingly used in business and industrial organisations (Harding, 1998). Indeed, it has become almost *de rigueur* to ensure the word is used when formulating economic and environmental policy (Robinson, 2002), and as expressed by Bell & Morse (1999), 'few development interventions or research initiatives these days can successfully attract funding unless the words "sustainability" or "sustainable" appear somewhere in the proposal to the funding agency' (p.3).

Such levels of popularity have been credited to the concept's vagueness (Daly, 1992; Reid, 1996; Bell & Morse, 1999; Dale, 2001), which has allowed widely divergent theoretical and ideological perspectives to come together in a single conceptual framework (Estes, 1993). In this sense, the concept is rather like truth, justice or democracy, in that they are all general notions not readily captured in concise definitions (Schaller, 1993 discussed in Bell & Morse, 1999). As noted by Reid (1995), people are generally in favour of such concepts, but retain their individual definitions as to what each means, and concede that they may actually be hard pressed to agree with others over how such ideals may be achieved.

Ambiguity and vagueness are reflected in the lack of a consensual definition for sustainability or sustainable development. The concept is amorphous in that it is perceived differently by different people (Batie, 1989), meaning that any interest group with it's own particular views over what, how, and for how long something should be sustained, can claim and justify their own respective usages of the sustainability term (Table 1.1). This, of course, has given rise to a veritable plethora of interpretations and definitions. By 1994, over eighty different variations of the WECD's definition for sustainable development had emerged (as discussed in Mebratu, 1998), growing to at least 200 by the turn of the century (Parkin, 2000), and more than 300 attempts to define 'sustainability' as a standalone concept have been put forward (Dobson, 2000 as discussed in Schmuck & Schultz, 2002).

Table 1.1: Examples of sustainability phrases

• sustainable living; sustainable way of life; sustainable futures	• sustainable development; ecologically sustainable development
• sustainable resource use; sustainable resource management; sustainable land management	• sustainable cities; sustainable business; sustainable industry; sustainable transport
• munitions sustainability; combat sustainability; sustainability of combat forces	• sustainable agriculture; forestry; fisheries; and other 'sustainable land uses'
• social, economic & environmental sustainability	• sustainable countrysides; rural sustainability

Lack of a consensual definition leaves the concept open to it's aforementioned misappropriation by any given interest group, skewing the essence of the concept across into institutional and group prerogatives (Mebratu, 1998). Such actions threaten to render the concept meaningless (Toman, 1999), with some suggesting that it has already been reduced to just a hollow cliché (as discussed in Mebratu, 1998). Today, the term is used wantonly to legitimise calls for unbridled economic growth, industrial expansion, globalisation, biodiversity and ecosystem protection, social justice, peace, and the elimination of poverty (Cocklin *et al.*, 2002).

Over-time, this may result in the sustainability term becoming redundant, and perhaps being replaced by a more fashionable alternative. However, it does not justify abandoning the pursuit of knowledge concerning the concept, as sustainability represents just another step in humankind's efforts to come up with 'set of ideas' for describing the present and future human/nature relation (Kidd, 1992). As such, rather than focusing on the fruitless search for universal definition, the emphasis should perhaps shift to understanding why the concept can have so many different and competing perspectives (Cocklin *et al.*, 2002). Likewise, in recognition of these multiple perspectives, there is more worth in specifically explaining the contextual application of the concept, rather than just relying on some generalised and all-encompassing version (Kidd, 1992).

The next section uses a systems perspective to explain why the concept can be so readily used to describe virtually any desirable state or process we would like to see continued over-time. This provides a conceptual framework that highlights not only the extraordinary complexity of the concept, but also goes someway towards clarifying some of sustainability's important but often overlooked dimensions.

A SYSTEMS PERSPECTIVE OF SUSTAINABILITY

In the broadest sense, sustainability is often used to describe the capacity for socio-ecological systems to persist unimpaired into the future (Gallopin & Raskin, 2002). However, the term has also been increasingly paired with virtually any context that implies a dimension of continuity. This can be expressed as environmentalists wanting natural ecosystems sustained; consumers wanting consumption sustained; works wanting jobs sustained; and even the military wanting their combat capabilities sustained. These and many other examples demonstrate that the sustainability concept has proven to be very amendable to application in a wide range of contexts.

Sustainability's breadth of application and ambiguity makes it particularly suitable to abstract interpretation through systems theory. In doing so, we can bring together themes and principles common to most contextual applications, and produce a model through which various definitions and interpretations can be examined. The key advantage of this approach lies in not having to initially accommodate the often confounding veneer of scholastic, political, and ideological clutter that seems to cling to sustainability like bad baggage.

1.3. FUNDAMENTAL SYSTEMS THEORY

Systems theory is the transdisciplinary study of the abstract organisation of phenomena, independent of their substance, type, or spatial and temporal scale (Dale, 2001). As such, systems can be used to represent the complex organisation of virtually any real-world entities into some form of ordered model that we can better understand.

In itself, a system can be defined as a set of components or subsystems that interact with each other (Clayton & Radcliffe, 1996), or alternatively as an aggregation of, or assemblage of, objects joined in regular interaction or interdependence: an orderly working totality. A system has at least seven characteristics:

1. ***Components*** or ***subsystems*** as the fundamental internal units of a system. While typically referred to as system components, they often represent subsystems with their own functions and resource flows.
2. ***Resources*** and ***resource flow***. System resources can be simplified down to energy, material or matter, and information (Clayton & Radcliffe, 1996). Resource flow is described as the input, throughput, and output of resources. Outcomes are intangible outputs or emergent properties (see below).
3. ***Relations*** as system internal intra-relations and external inter-relations. Relations represent resource flow pathways.
4. ***Control & regulation mechanisms*** that add order and coherence to a system. These can be subsystems unto themselves, becoming more distinguishable and important with increasing system complexity. Also known as communication and feedback-loops as a part of system cybernetics (Valentine, 1991; Dale, 2001).
5. ***System boundaries*** that encompass components and internal relations. Boundaries can be difficult to distinguish in reality because external relations often have the effect of blurring where one system stops and another starts.
6. Internal ***hierarchy*** representing levels of relative system complexity. Lowest tiers represent basic system components that interact to build successively higher and more complex tiers.
7. ***Emergent properties*** representing 'something extra', as they cannot be explained solely through examining the sum of a system's parts. Ideas of holism and synergy are often used to explain emergent properties.

1.3.1 ENVIRONMENTAL SYSTEMS

The term 'environment' is often used loosely within the sustainability debate. While originally coined to describe the relation between organisms and their surrounding ecosystems, the meaning of the term has evolved to also encompass humankind's relation with our heavily modified socio-ecological systems. Hence, it may legitimately be used in both ecocentric and anthropocentric senses, which can create confusion between diametrically opposed interest groups both arguing for protection of their own respective versions of 'the environment'.

However, there are a number of environmental principles that transcend this confusion. Firstly, all environments are defined by being concentric. A dictionary definition of environment is 'that which encompasses an object [and] the sum of external influences' (Cassel, 1994). This implies a central context surrounded by everything else that has an inward influence. This distinction is more apparent with the French word for environment *milieu*, where *mi* means middle and *lieu* means place – literally 'middle-place'.

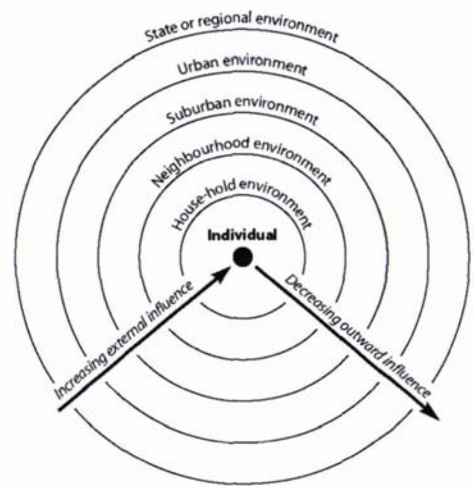


Figure 1.1: Hypothetical socio-ecological environment of an urbanite

Secondly, influence flows two ways in an environment. A central component will influence or impact upon it's surrounding environment, and the environment will in-turn influence the component itself. As noted by Cronin (1988), 'living things do not merely live in and adjust to their environment, they continually create it and change it' (p.23). This degree of influence is abstractly proportional to the distance away from the centre, or in a systems context, proportional to the strength of a relation. This gives rise to environmental hierarchies, such as the hypothetical socio-ecological environment of an urbanite (Figure 1.1).

Thirdly, the environment concept is not constrained solely to ecosystem applications. Particularly with human systems, environments can be reduced to their component subsystems to better explain the influence of a targeted set of factors without the confusion inherent to higher order systems. Hence, while we can talk about a person's 'wider environment', we may also use the concept to describe their social environment, working environment, learning environment, household environment, and so on.

1.3.2 THE INTEGRIST SYSTEMS MODEL OF SUSTAINABILITY

A discussion on sustainability from a systems perspective would be incomplete without at least touching on the integrist systems model. Also known as the 'academic version' or the 'three dimensions of sustainability', the integrist model is so called because it does not separate-out the three principle systems considered integral to the sustainability concept. Rather, sustainability is defined as the conceptual intersection, interaction, and integration of our economic, social, and ecological systems (Figure 1.2).

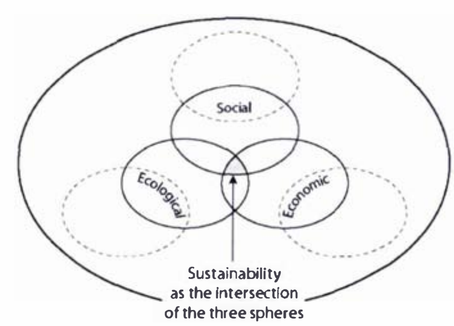


Figure 1.2: The integrist systems model of sustainability

While this model is popular and easy to understand, it does have a number of limitations. Firstly, the model is fixed within an anthropocentric context, as the central goal of sustainability can only be achieved when society's collective social, economic and ecological objectives are all reconciled together at the same time. This implies ecological sustainability cannot be attained independently from the other two dimensions of sustainability. Secondly, the model relies on the assumption that social, ecological and economic objectives can actually be reconciled. In reality, many of these objectives are often in conflict, or at worst, they can be diametrically opposed (e.g. exponential population growth *vs.* improved biodiversity). Finally, the model conveys no sense of time. As will be discussed, the time dimension is pivotally important to any interpretation of the sustainability concept.

1.4. SUSTAINABILITY IN SIMPLE SYSTEMS

At face value, sustainability is a noun constructed upon the two adjectives *sustain* and *ability*, which when taken together literally mean the 'ability to sustain'. To sustain is defined as 'to support or nourish' (Cassel, 1994), which implies a dependent relation (i.e. something supporting or nourishing something else). Generally, physical objects are *supported*, while biological forms are *nourished*. As examples, the weight of a bridge is supported by it's structural foundations, while the growth of a child is nourished by the food it consumes. In each case, the word *sustained* can be used to replace both *supported* and *nourished*.

The term *ability* implies a capacity or function that can fulfil something's requirement or need. In a capacity context, a pool or sink has an ability to accept, store and supply resource, while in a function context, a cybernetic[1] system has an ability to regulate, control and adjust system function. Hence, the *ability to sustain* can refer to both a state (as the latent or potential capacity to sustain) and a process (as the act of sustaining), or in the case of complex adaptive systems, it can simultaneously refer to both (as quasi-stable or steady states).

Examined in a simple systems context, these relations can be described as *one system sustaining the requirements of another system* (Figure 1.3). System A has a capacity to sustain System B, and implicitly, System C has an ability to control the relation between it's two subsystems. However, the central relation is a unilateral one, meaning System A will eventually be depleted of resource if not replenished, while System B will either grow or become overloaded depending upon it's processing abilities.

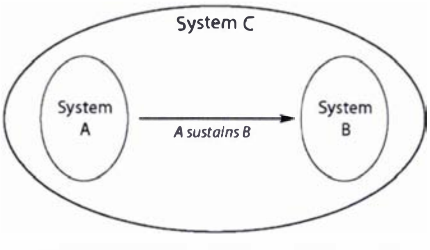


Figure 1.3: One system sustaining the requirements of another system

As a closed system, many would consider the relation between A and B as being clearly unsustainable. The ability of A to sustain B is limited, and therefore the relation cannot be sustained for an extended period. However, consider the relation between the sun and life on earth. The sun contributes to sustaining life by providing a constant source of energy in the form of light. Light is converted to more useful forms of energy by plants and other organisms, which in-turn is available to herbivores, predators, decomposers, and the whole life cycle. And yet, while the sun will eventually end the relation by consuming itself and dying, we wouldn't usually consider this as an unsustainable relation.

[1] *Cybernetics – the comparative study of control and communication mechanisms in machines and living creatures (Cassel, 1994).*

1.4.1 SUSTAINABILITY OVER-TIME

The relation in Figure 1.3 is sustainable because time is relative. Systems function over their own timeframes (Ehui & Spencer, 1993; Bell & Morse, 1999), such as eons for geological systems, decades for humankind, and several days for the life of an insect. However, we tend to perceive the longevity of systems relatively against our own human timeframes. Hence, a bee that exists only for a few days is considered to have a short lifespan, while a tree that continues to grow for several hundred years has a long lifespan. This relative perception of time has important implications regarding sustainability.

Firstly, there is an assumption that human consumption of non-renewable resources is unsustainable. However, it cannot be denied that the present use of non-renewable resources is currently sustaining existing lifestyles and developments, even if at some point in the future the resources must be exhausted. Hence, it is perhaps more appropriate to state that the future use of non-renewable resources for human purposes is sustainable *for a given period of time*. As an example, phosphate reserves are exploited around the world to sustain current levels of food production. Phosphate reserves are optimistically estimated to last for another 450-670 years (Fert Research, 1998). Accordingly, our reliance on phosphate rock for food production is sustainable for the next 450-670 years.

Secondly, we have an ability to extend the period for which a resource may be sustainably used. Returning to the simple system of Figure 3, the flow of resources between System A and System B can be slowed by cybernetic intervention by System C, thereby extending the life of the entire system. In everyday terms, this represents a form of conservation or resource management, through which resources are consciously and judiciously 'metered out' to extend the period for which they may be used. However, in being a conscious action, someone must decide for how long resources are to be conserved. For a person concerned with their own individual well-being, this may only be a few decades, while a person concerned about the continued well-being of a community, nation or humankind as a species, may seek to conserve resources for hundreds of years.

This relates closely to the third point. Can a system be sustained indefinitely? Obviously this is desirable if humankind wants to avoid extinction, but according to fundamental laws of physics, all systems must follow a pattern that eventually ends in non-existence (Section 1.5.2). Hence, it may be naïve to assume sustainability can mean 'going continuously forever' as suggested by some commentators (e.g. Vucetich, 1990; Jordan, 1995). Rather, in cases where we cannot foresee the absolute limits of a sustaining relation, it is perhaps more appropriate to ascribe an indefinite time dimension rather than an infinite one. In popular anthropocentric definitions, this is often achieved by stating 'for present and future generations', to refer to an 'unspecified number of generations of humanity *en mass*' (Reid, 1996, p.xvi).

Fourthly, that which is considered sustainable can change over-time. New technology or understanding may arise, that may highlight an activity as being unsustainable when it was previously thought otherwise. Conversely, science and technology are regarded as a panacea to some, through which the unsustainable will become sustainable over-time. Similarly, changing needs can alter what is meant by sustainability. A farmer whose land comes under threat from urban sprawl may legitimately adopt practices that degrade the quality of agricultural land, as there is little reason to protect the productive integrity of this resource if in the near future it will be covered in bitumen, paving and housing.

The practical offshoot from this discussion is that our perception of time lies at the heart of any sustainability interpretation (Bell & Morse, 1999). Accordingly, it makes sense to at least attempt to ascribe an explicit time dimension to a given contextual application of the concept, although it is recognised that this is not always possible (i.e. for indefinite timeframes). Despite this, the inclusion of a time dimension represents one means of introducing some degree of clarity into the sustainability debate.

1.5. SUSTAINABILITY IN COMPLEX SYSTEMS

Simple systems are useful for introducing some of sustainability's complexities, but rarely do they adequately reflect real-world systems. When we examine resource flows more closely, we often find that seemingly simple relations are actually made up of a series of sustaining relations (Figure 1.4). One system sustains the ability of a following system to sustain another system, and another system, and so on (e.g. the flow of energy through various trophic levels of a harvested marine system). This introduces the idea of 'sustaining the ability to sustain', or building on our earlier description, *the ability of one or more systems to sustain one or more systems, over-time.*

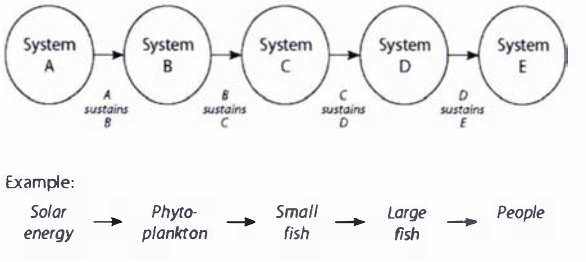


Figure 1.4: Linear sustaining relations

In complex systems, many of these relations are directly or indirectly cyclic, and therefore somewhat self-sustaining. Returning to our earlier model, System A could sustain System B for a longer timeframe if the relation was mutual rather than unilateral (Figure 1.5). However, such simple relations are rarely distinguishable in reality, because the form in which resource is exchanged will determine whether or not a given system can make use of it. Rather, the resource often has to go through a number of systems and transformations before returning to the original system in a suitable form (Figure 1.6). Recycling in ecosystems is an expression of this principle.

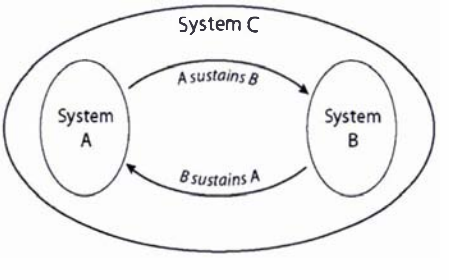


Figure 1.5: Mutual sustaining relations in a simple system

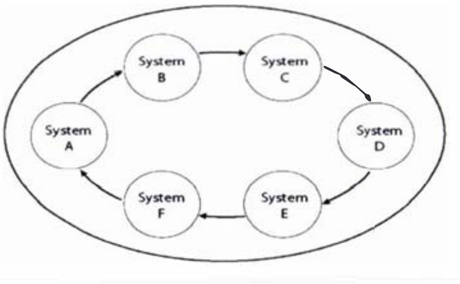


Figure 1.6: Mutual sustaining relations as recycling

1.5.1 MULTIPLE SUSTAINING RELATIONS

Recycling is a common theme in real-world systems that extends the ability to sustain over-time. Classic examples include the carbon cycle, various nutrient cycles (particularly nitrogen, potassium and phosphate cycles), the hydrological cycle, the energy cycle, and the decomposition cycle. All these cycles interact together, at the same time, to create an extraordinary complexity of multiple sustaining relations.

Part of this complexity can be portrayed by taking a static look at multiple relations from a systems perspective (Figure 1.7). Building from a simple system, System A can have a number of step-forward sustaining relations. Consider a hen in a farmyard: as a complex organism, a hen is sustained by the air it breathes, the water it drinks, the shelter provided by the henhouse, and the nutrition it gains from multiple sources of food. Each factor supplied represents a separate sustaining relation unto itself. Hence, the life of the hen is sustained through multiple relations.

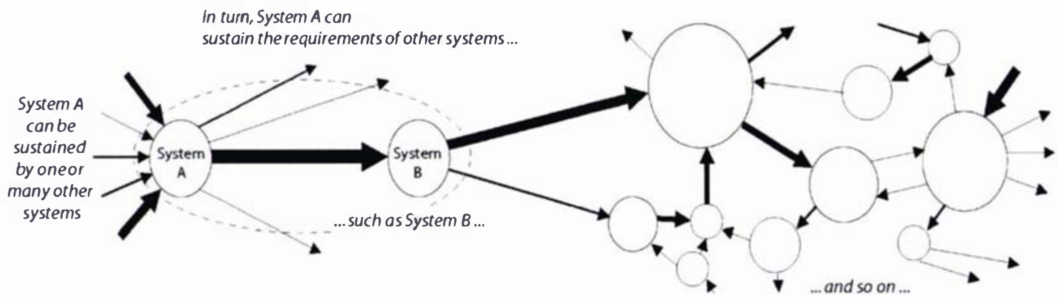


Figure 1.7: Multiple sustaining relations

Continual input of resources from single or multiple sources will convey an increased ability to sustain follow-on systems, such as System B. Likewise, System B can sustain one or many other systems, which in turn sustain other systems, and other systems, and so on. So returning to our hen, this organism may in-turn directly contribute to sustaining a diversity of parasites, the farmer's nutritional needs as eggs or meat, or if the hen is sold as produce, then it may indirectly contribute in some small way to sustaining the farm business, markets, jobs, and so on. The point being, is that a single system can sustain many other systems through multiple relations, directly and indirectly.

1.5.2 OPEN AND CLOSED SYSTEMS

Multiple relations are a characteristic of open systems, whereby resource can flow across system boundaries. This contrasts against the closed systems previously depicted in Figures 1.5 & 1.6 that only have internal resource flows. Provided closed boundaries remain intact and internal recycling continues, then such closed systems can hypothetically remain self-sustaining indefinitely.

However, no real-world system can remain closed forever. Often that which we regard as being closed, is actually functioning on temporal and spatial scales well beyond our immediate human realities. As an example, the earth is typically regarded as a closed system, even though this overlooks the massive fluxes of energy and particles that pass between the atmosphere and space over geological timeframes. Nor does it acknowledge that planets form and inevitably collapse over galactic timeframes. Such dynamics are generally overlooked because they occur outside our temporal and spatial frames of reference.

No system can stay forever closed due to fundamental laws of thermodynamics. The first law states that energy can neither be created nor destroyed, but only changed in form. In other words, energy flowing into a system must eventually flow out of the system, even though it may be represented in different forms. Recycling can negate this somewhat, by continually changing energy back into useful forms. However, it cannot account for the second law.

The second law states that no transformation of energy is ever 100% efficient. Rather, any transformation will result in the degradation of energy from an ordered available form (concentrated) into an unavailable disordered form (dispersed). This is known as entropy, defined as a measure of system disorder based on the amount of unavailable energy within that system (Dale, 2001). This law does not distinguish between matter or energy (Georgescu-Roegen, 1975), and perhaps information also, meaning all systems are ultimately subject to entropy.

Entropy implies all systems have a limited lifespan, moving from an organised state to a disorganised state, eventually becoming dysfunctional and disintegrating or dying (Clayton & Radcliffe, 1996). It also implies that a reverse process is at work (Dahl, 1996), where order and coherence are being built-up. This is negentrophy or 'negative entropy' (Dale, 2001). Taken together, negentrophy and entropy represent the growth and decline phases of system dynamics.

1.5.3 SYSTEM DEVELOPMENT AND SUSTAINABILITY

The principle that no system can be eternally sustainable is often hidden through the dynamics of higher order systems. This can be expressed as development phases dictated by negentrophy and entropy; as steady-states that fluctuate across a quasi-stable growth and decline equilibrium; and as the extraordinary complexity of adaptive systems continually breaking and forming multiple sustaining relations.

All systems go through a development process, characterised as having a beginning, a growth phase, an apex, a decline phase, and eventually an end. Again, this process may be inadvertently overlooked because many systems function over temporal and spatial timeframes difficult to comprehend within our short human lifespans. However, the state or phase a system is currently undergoing has important implications regarding it's sustainability.

A growing system requires a maintained or increasing level of resource input, respectively paired with either a decreasing or maintained level of output (Figure 1.8). Within such a state, excess amounts of resource can be assimilated to fuel and structure growth. A declining system (Figure 1.9) has the opposite resource input and output relations, and essentially consumes itself to maintain an ever decreasing plane of function.

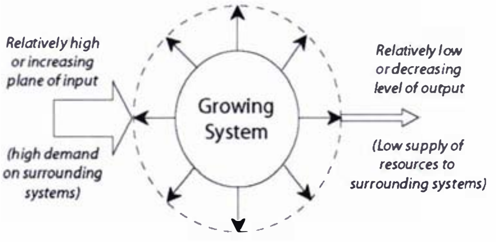


Figure 1.9: Relation of system growth to changing levels of resource input and output

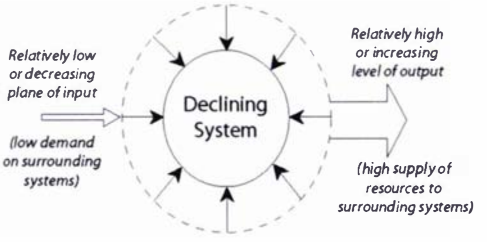


Figure 1.8: Relation of system decline to changing levels of resource input and output

From one perspective, a growing system reduces the sustaining ability of surrounding systems by locking-up resource. Resources are limited, meaning the growth of one system must result in the decline of surrounding systems. However, over the long term, a growing system is enhancing it's potential ability to sustain surrounding systems, because eventually it must enter a decline phase and release resource. Whether or not we consider these phases as being sustainable again depends upon our perception of time, and perhaps more significantly, the level of importance we ascribe to a system (Section 1.5.4).

A compromise state or phase between growth and decline is stability. A stable system is characterised by having unchanging levels of input and output, with the set throughput being sufficient to meet ancillary subsystem needs not sustained through internal recycling. System size and level of order can be maintained, and the system could hypothetically continue to sustain surrounding systems at set levels for both the short and long term.

However, a system is only as stable as the stability of it's surrounding environment. External perturbations beyond the system's control can interrupt resource flows. Competition is the classic example, where the pursuit of scarce resources by other systems in the surrounding environment can result in reduced system input. On a larger scale, ideas of catastrophism highlight the fragility of systems operating over short timeframes, to perturbations in systems that function across much greater temporal and spatial dimensions (e.g. climatic, geological, and astrological systems).

Some systems have an active ability to respond to environmental change (Clayton & Radcliffe, 1996). These are known as adaptive systems, as they are constantly breaking and forming multiple sustaining relations in response to environmental opportunities and limitations. In general, higher order systems are adaptive, such as climate/weather systems, biological systems, and many of our social and economic systems, including markets, communications, cognition abilities, and social interactions. Most of these systems can modify internal function (adapt or evolve), actively secure external resource (compete), and some can make use of surplus resource in the production of hereditary systems (e.g. reproduction).

Adaptive systems add a whole new flavour to system stability. Relations that are no longer sustaining can be broken, while new relations can be actively established to replace them. In a sense, a system can continually fluctuate between growth and declines states, with the net effect being expressed as a steady-state or quasi-equilibrium.

This means that sustainability is an extraordinarily complex concept. A small part of this complexity can be captured by reconsidering the two dimensional model previously depicted as Figure 7. As a dynamic model, this diagram would expand to fill up the page, and then flow out to conceptually cover an indefinite area. Circles representing systems would continually appear, expand, decline, and then disappear in a seemingly random pattern. Arrows representing sustaining relations would be similarly winking in and out of view. And finally, rather than just two dimensions, this dynamic display of complexity would actually be occurring in three spatial dimensions.

It is at this point that our earlier description of system sustainability breaks down somewhat. *The ability of one or many systems to sustain one or many systems over-time* still holds true, but it is largely useless in a practical context unless we can identify what systems are being sustained, and which systems are doing the sustaining. The dynamic complexity of systems constrains us from achieving this. However, this complexity is not completely chaotic and random, meaning there are discernable patterns that science continually seeks to map. Hence, we can often account for obvious and direct sustaining relations through current tools and understanding, but in recognition of the unknown, we must continue to rely on ideas of emergent properties, synergy and holism.

1.5.4 THE WHAT, WHY, HOW AND FOR HOW LONG OF SUSTAINABILITY

Although the preceding discussion is somewhat esoteric, it does include an important principle useful for clarifying the contextual application of the sustainability concept. That is, when we state that something is sustainable, we are often inadvertently referring to the dual context of 'sustaining the ability to sustain'. Put another way, we are not only interested in 'what' is being sustained, but because sustainability often implies purpose and continuity, we are also interested in 'why' or 'how' a system is being sustained (Figure 1.10).

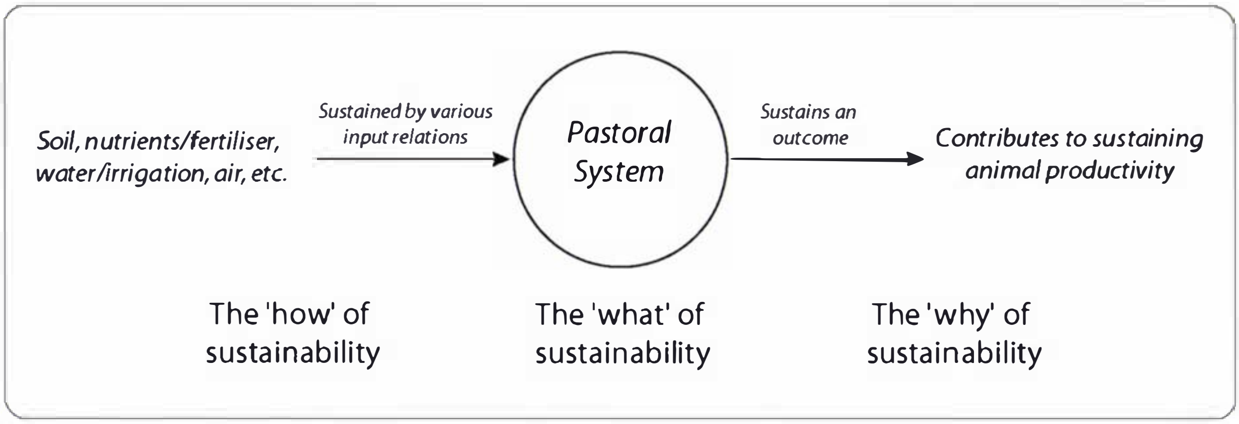


Figure 1.10: The what, why and how of sustainability for a pastoral system

For a pastoral system of interest (the 'what'), we may be interested in it's ability to sustain animal productivity (the 'why'). In reverse fashion, we may also be interested in 'how' the system's animal sustaining abilities are being sustained. In doing so, we can gauge the all important 'for how long' temporal dimension, and as a managed system, we can intervene to maintain or enhance pastoral sustainability through irrigation, fertilisers, and grazing conservation.

It follows, that the idea of 'sustaining the ability to sustain' can be applied in either a step-forward or a step-back sense, as the 'why' or 'how' of sustainability. Coupled with the 'what' and 'for how long', either sense can be used to introduce a little more clarity to specific applications of the concept (Figure 1.11). However, this contribution can only be small when applied to complex and dynamic systems, as we often have to rely on generalisations to explain complexity and emergent properties.

The environment's ability to sustain *life* / *An indefinite period*	*The environment's* ability to sustain *human life* / *An indefinite period*	The ability of *a house's foundations* to sustain *the weight of the building* / *The life of the house*
A soil's ability to sustain a *plant's growth* / *The life of the plant*	*A farm system's* ability to sustain *the farm family* / *The life of the farm family*	*A university's* ability to sustain *the interest of a student* / *The student's academic career*

Figure 1.11: Examples of 'the ability of one or many systems to sustain one or many systems over-time'

Often the easiest way to describe complexity is to lump it all together as a conceptual generalisation. The 'environment' is one such example. While we can legitimately qualify this as 'the environment's ability to sustain our modern lifestyles indefinitely' as with a version of anthropocentric sustainability, it is – like many similar definitions – very ambiguous and open to a wide range of interpretations.

However, generalisations are usually reserved for application at higher levels of complexity, such as sustainable development, sustainable resource management, sustainable agriculture, and so on. As noted by Reid (1996) in a global issues context, 'though it may be difficult to trace all the connections, especially on a small scale, many important linkages can be identified' (p.22). Hence, at more localised scales, we can be more specific with the sustaining relations we identify, which is particularly important when attempting to manage and develop them. Unfortunately, the importance of hierarchy is often forgotten in the sustainability debate.

1.5.5 Hierarchies of sustainability

System hierarchies represent increasing levels of complexity, beginning from the interaction of simple systems, and successively building-up to higher order systems. As a concept, hierarchies can be readily applied to virtually any context characterised by having successive divisions of order, size, complexity, rank, sophistication, and so forth. Natural hierarchy may be spatially expressed as the ecosphere, biomes, ecosystems, ecological regions, and then down to the somewhat interchangeable ecological districts and domains. Socio-ecological hierarchy can be divided into the world, countries or nations, regions or states, districts or provinces, and then alternatively divided down to either cities, suburbs, neighbourhoods and households, or rural settlements, farms, and then households again. Previously discussed environmental hierarchy can be used interchangeably between ecological and socio-ecological systems to describe tiers of influence.

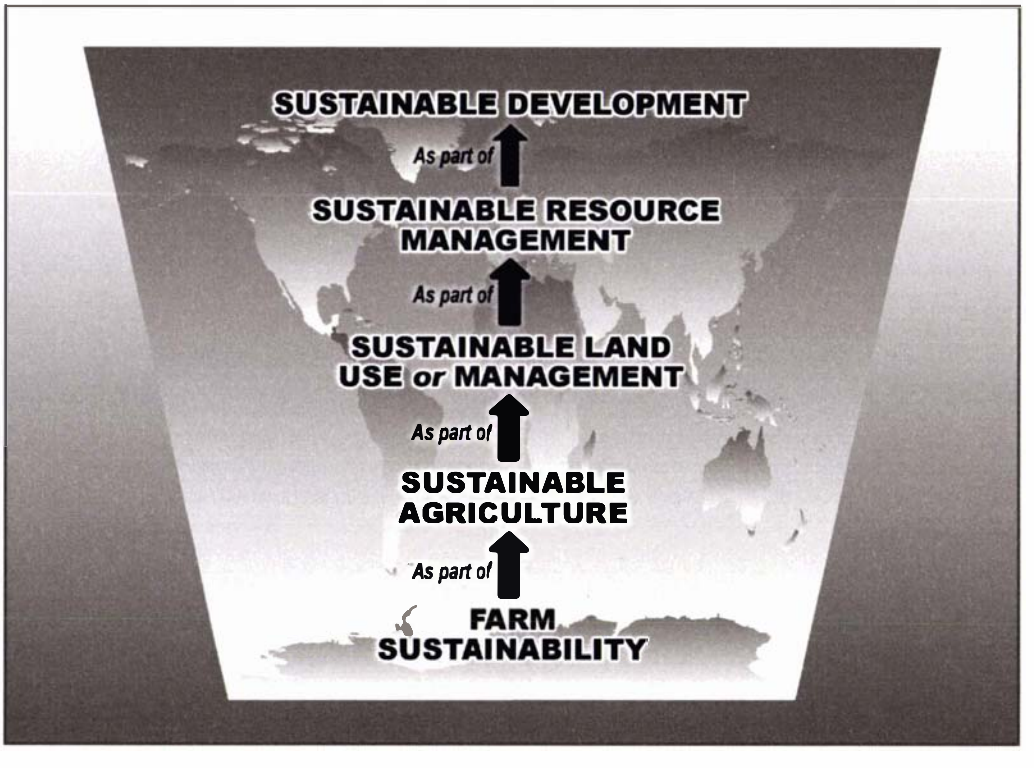


Figure 1.12: Hierarchy in sustainability from an agrarian perspective (adapted from Dumanski, 1997)

Hierarchy within the sustainability debate is characterised as various tiers of interpretation or definition (Figure 1.12). Hence, we can begin with farm sustainability as agriculture's smallest decision-making unit, which is a part of, or contributes to sustainable agriculture. That is, the collective sustainability of individual farms contributes to sustaining the agricultural industry. Agriculture is one of many potential land uses, so in turn contributes to sustainable land use or land management (considered here as being essentially synonymous). Land is one of many resources contributing to sustainable resource management, all of which eventually come together with other less-agrarian orientated sub-interpretations as sustainable development.

Unfortunately the distinction of hierarchy can be overlooked in the application of sustainability. Whereas a generalised interpretation may be necessary for policy formation at national and international levels, it's lack of specifics and detail will have little value at the grassroots level. Hence, the dictum 'think globally but act locally', which is a recognition that sustainability cannot be imposed top-down from upper tiers (Reid, 1996). Conversely, as there can be many possible sustaining relations involved, upper tier interpretations may become bogged down by seeking to include too many specifics.

Take sustainable land management as an example. In a system's context, it can be expressed as the ability of human management to sustain land for an undefined period, and for an undefined purpose. This is remarkably vague, and therefore highly suitable for application to any context that involves land management (agriculture, forestry, recreation, protection, etc.). However, popular interpretation has been skewed towards agriculture, and defined in terms of management's ability to sustain land's agricultural productivity and integrity, along with sustaining the land use's socio-economic viability and security (e.g. Neave *et al*., 1995; Cornforth, 1998). Such definitions are no- longer generically applicable to all contexts of land management (e.g. protection management does not need to be economically viable), but tend to be more in-tune with ideas of farm sustainability.

Hence, along with the 'what, why, how, and for how long' of sustainability, explicitly stating the level at which the concept is being applied is another means of introducing a degree of clarity into contextual applications. However, as with the other criteria, there is a limitation that can make this difficult. As all systems are directly or indirectly linked, so to are the hierarchical tiers of sustainability (Niu et al., 1993; Bell & Morse, 1999). Different divisions do not necessarily have absolute boundaries or cut-off points, meaning it can problematic deciding the degree of detail to attach to an interpretation. To a small extent this is overcome by identifying the 'how, what and why', but again, all conceivable sustaining relations cannot be reliably mapped.

1.5.6 THE 'WHO' OF SUSTAINABILITY

The final dimension of interest takes us back to the human/nature debate. As complex adaptive systems unto ourselves, humankind as demonstrated a remarkable ability to appropriate, modify and manage systems, allowing us to develop an increasing degree of control and influence over many, if not all, of the world's ecosystems. Such dominance has implications for the 'what, why, how and for how long' of sustainability, because rather than nature, many of these criteria are now decided by people. Hence, the 'who' of sustainability becomes integrally important to applications of the concept.

Different interests want different systems sustained, which is a function of how people view or perceive the world. At polarized extremes, those with strongly ecocentric views want ecosystems sustained for their intrinsic value, while those with strongly anthropocentric views want these and related systems sustained for human purposes. Each interest has an individual 'worldview' or 'paradigm', defined as a complex of assumptions about goals, strategies and procedures (Reid, 1996), as determined by our attitudes, norms, beliefs, understanding, values, realities, habits, priorities and other such ethereal considerations inherent to the way we think and interact with the real world.

When people with similar views come together we can have a 'common interest' or an 'interest group', all of which argue for their own perceptions of what should be sustained, how it should be sustained, why it should be sustained, and even occasionally for how long should it be sustained. At the society or national level, the population's view aggregates as the prevailing or dominant paradigm/worldview.

The reasons why we seek to sustain different systems in different ways is the domain of psychology, sociology, and other disciplines that seek to describe human behaviour. Accordingly, it is not discussed in detail here, despite being fundamentally important to interpretations and applications of the sustainability concept. Rather, the importance is acknowledged, with a recommendation that contextual applications of sustainability be qualified by attempting to include the underlying perspective or worldview. In doing so, another small part of the confusion that surrounds the sustainability concept can be overcome.

1.6. SYSTEM SUSTAINABILITY - SUMMARY

Sustainability has a literal meaning as the ability to sustain. Expanded, this can be interpreted as a function or capacity to either support or nourish something else. As such, application of the concept can be related to a process or an activity in a dynamic sense, or to a state in a capacity sense.

From a systems perspective, sustainability can be further interpreted as the ability of one or many systems to sustain one or many systems, over-time. This means that the sustainability concept can be applied to describe virtually any conceivable real-world relation between two or more systems that exhibit a dimension of continuity.

The sequential ability of systems to sustain can be expressed in either a linear or cyclic fashion, or in the case of complex adaptive systems, as an ever changing play of system development and multiple sustaining relations. The dynamic and complex nature of systems sustainability limits our ability to identify, understand and manage sustaining relations.

Six important dimensions of sustainability emerge from a systems perspective. The 'what' of sustainability identifies the system of interest; the 'how' describes step-backward relations that underpin continuity; the 'why' provides an indication of purpose in a step-forward sense; and the 'for how long' brings it together as the all important time dimension. The 'who' of sustainability is a recognition that humankind's dominance allows people to actively decide the what, how, why, and for how-long of sustainability for many of the world's systems. Finally, hierarchy provides a scale of generality, ranging from specific interpretations important for practical applications at the grassroots level, through to upper tier interpretations that generalise complexity for broad conceptual applications such as national and international policy.

Although each of these six dimensions can rarely be clarified in their entirety, they do have a value towards reducing some of the confusion that surrounds contextual applications of the sustainability concept. This is explored in the next section, where the six criteria are combined with a seventh to interpret farm sustainability.

FARM SUSTAINABILITY

This section looks broadly at a generic model of farm sustainability as it relates to conventional pastoral farming systems in New Zealand. However, rather than a context of 'a farm's ability to sustain' external relations, the discussion is more concerned with internal sustaining relations. In doing so, we can highlight how cybernetics regulate system integrity as a self-sustaining ability.

1.7. FARM-INTERNAL DIMENSIONS OF SUSTAINABILITY

Systems are dimensionless. Any given system may encompass an infinite number of subsystems, or conversely, all systems are part of larger systems. Hence, while we may single-out a system of interest, it will inevitably be part of a conceptually endless continuum. In spatial reality, this can be expressed as the two polar uncertainties of existence beyond sub-atomic particles, and whether or not there is anything larger than the universe.

This has an important implication for system sustainability. The preceding discussion highlighted the ability of one system to sustain another system in an external context – resource is supplied to a system, thereby increasing it's ability to supply follow-on systems with resource. However, as systems are dimensionless, the very same types of relations are taking place within the system of interest. This may be expressed as system function and control, both of which translate to an ability to self-sustain in an internal sense.

Farm sustainability is a good example of internal and external sustaining relations. Externally, a farm is sustained by a constant influx of resource – water from weather systems, information from communication systems, nutrients from fertiliser systems, machinery from manufacturing systems, and so on. Reciprocally, a farm directly contributes to sustaining rural economies, markets, society's food and fibre requirements, and other dimensions of the agricultural industry. Internally, a farm boundary encompasses social, economic, production and biophysical systems, all interacting through various self-sustaining relations as regulated by management.

1.7.1 THE 'WHAT' OF FARM SUSTAINABILITY

The farm unit is the 'what' of farm sustainability. However, because the internal dimension of a farm's ability to sustain is being discussed, it is relevant to outline the principle subsystems conceptually encompassed by a farm boundary (Figure 1.13).

Social system: Comprises the farm family, farm owner, employees, and the farm manager, or any other person who physically resides within the farm boundary, or has direct influence over farm management decisions.

Economic system: Also known as the farm business unit, this system is concerned primarily with purchases, income, profitability, taxation, and any other flow of finances directly concerning the farm. Also includes the 'home economics' dimension.

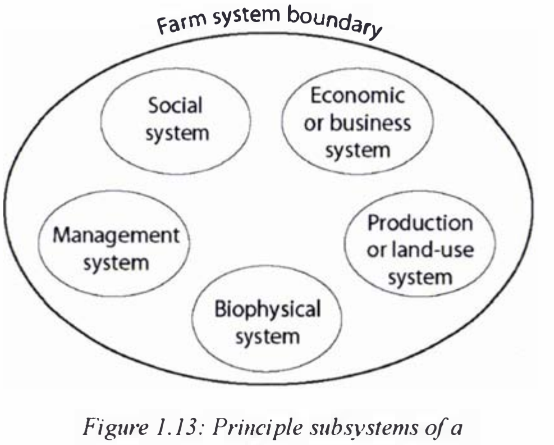


Figure 1.13: Principle subsystems of a farm

Production system: This may be interpreted as the land use system, as it represents the interface between the farm's socio-economic system, and it's underlying biophysical system. In a similar sense, it is also known as the agro-ecological system, in recognition that it represents the part of an ecosystem that has been appropriated, modified and managed for agrarian purposes.

Biophysical system: This represents the underlying resources and processes upon which the production system is designed and managed. The distinction is very vague, but is perhaps best characterised as production orientated resources that have been introduced, heavily modified, or are intensely managed, as compared to ecologically oriented biophysical resources that still retain much of their autonomous functioning capacity. While the latter may be influenced by the farming operation, for the most part they are still controlled by nature. Nutrient recycling in soils is an example. Biophysical resources generally include soils, surface and ground water, climate, landform, and vegetation in some contexts, all of which fall comfortably within some interpretations of 'land' (Chapter 3). Accordingly, those seeking to promote sustainable land management often tend to focus almost myopically on the sustainability of a farm's biophysical system.

Management system: Management is obviously part of the social system because it represents a human activity. However, it deserves it's own distinction as the system that transcends all farm internal systems, and usually regulates the function of both the production and business dimensions of a farming operation. It represents the cybernetic system of the farm, in that it receives information on the state of the system; compares it to the required state or condition; and can intervene to manipulate and control system function to correct deviations.

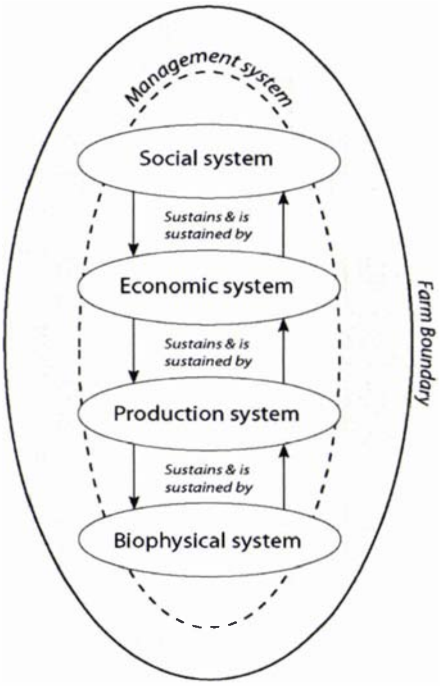
Farm boundary: This is a social construct (as a cadastral property), expressed as a physical construct (e.g. a fence), to encompass part of the landscape within-which the production system operates. As social-physical constructs, farm boundaries do not necessarily conform to biophysical or 'natural' boundaries (e.g. watersheds, soils, landforms, ecological units).

While a distinction of these subsystems and components can be made abstractly, in reality they cannot be so readily separated. Each flows into the other, representing an internal complexity of sustaining relations.

1.7.2 THE 'HOW' AND 'WHY' OF FARM SUSTAINABILITY

The 'how' and 'why' of farm sustainability represent sustaining relations. Internal and external feed-in and feed-out sustaining relations are numerous and complex, and are still well beyond the current level of agricultural science. Few, if any, whole-system models have been put forward, although specific progress has been made with the modelling of ruminant digestion, soil erosion, surface and subsurface hydrology, nutrient recycling, pasture management, and other such internal systems. Similarly, links with many external systems, such as markets, economics, and climate, are reasonably well understood, but their dynamic nature often resists reliable prediction and modelling.

Internally, sustaining relations between subsystems are often indirect, mixed-up, and thus can be difficult to model in a whole farm context. One possible example of direct sustaining relations between subsystems is provided (Figure 1.14), but for the sake of simplicity, it ignores many other important relations integral to modern farming systems. In brief, the ultimate internal purpose of the farm is to sustain the social system (the ultimate 'why'), which is sustained directly by the economic system, which in-turn is directly sustained by the production system,



all of which are sustained by the underlying biophysical system. Inverse relations can be expressed in a similar manner (as the 'how'), perhaps best captured as the social system sustaining the function of other subsystems through management.

All of a farm's internal and external relations, no matter how small or brief, will in someway contribute to whole-farm sustainability. As such, they are all important in their own way. However, the sustainability of some systems is more directly important than others (at least for human purposes), and as such, can be singled out as primary factors determining farm sustainability. Here they are considered as biophysical sustainability, environmental sustainability, and the ability of management to sustain farm function through design and control.

Figure 1.14: One possible example of direct or linear sustaining relations within a farm system, from an anthropocentric perspective

1.7.2.1 The importance of biophysical sustainability at the farm level

In a farming context, biophysical sustainability can be interpreted as *the biophysical system's ability to sustain the production system* (it sustains other systems also, but the production system is of central importance from an agricultural perspective). As discussed below, each farm in NZ has a more-or-less unique biophysical base, meaning that the inherent capability to sustain each farm's production system is similarly unique. As an example, the biophysical base of a Waikato dairy farm is likely to have a high inherent ability to produce, as compared to a dry Hawkes Bay hill country farm. Rephrased, the Waikato farm carries an inherently higher productive potential than the Hawkes Bay farm.

This is often expressed as *land capability*, which essentially represents a comparative empirical measure of land's biophysical sustainability for agricultural purposes. Land capability has been mapped throughout NZ according to naturally occurring biophysical boundaries, using various systems of land classification (Chapter 5).

In short, the underlying biophysical system is critically important to whole-farm sustainability because it represents the *inherent* productive potential of a farm. It is the foundation upon which the rest of the farm system is built upon. With our modern-day farming systems, management's ability to sustain can be enhanced with a greater explicit understanding of biophysical sustainability and land capability (Chapter 3).

1.7.2.2 The importance of environmental sustainability at the farm level

It may be pertinent to remind the reader that the concept of 'environment' transcends ecocentric connotations when applied to human systems such as agriculture (Section 1.3.1). In this case, the farm is the concentric entity of interest, meaning a farm's environment includes everything that influences farm sustainability in an inwards sense, and conversely, everything that a farm's operation influences in an outward sense. Hence, environmental sustainability is a generalisation used to group the dynamic complexity of all external sustaining relations.

Environmental sustainability is important because conventional NZ farms appear to be increasingly dependent on external relations. This is readily envisaged by comparing the relatively closed function of a pioneer farm with our increasingly open modern-day conventional farms. In yesteryear, a farm family's consumption needs were fulfilled almost completely from the food and fibre produced within-farm, while today, a farm family may fulfil these and more affluent needs from produce sourced from virtually anywhere around the globe. Likewise, early farm systems have evolved from low-intensity systems using only minor additional inputs, to today's intense high input/output systems linked to complex global markets, logistic systems, communication and information systems, quality control systems, and so on.

Openness of conventional farming systems creates a high degree of susceptibility to external perturbations and change. Significant environmental fluctuations in climatic, ecological, economic and social systems can threaten farm sustainability, if the farm in question cannot either adapt to the change, or buffer the change if it is short-term in character.

1.7.2.3 The ability of management to sustain farm function

The ability of management to sustain farm function is the third factor that has the greatest direct influence on whole-farm sustainability. It is also the most important, because management is responsible for designing and operating a production system that fulfils socio-economic needs. Such a design should account for inherent biophysical capabilities and limitations; be secure and flexible to buffer and adjust to external change; and be regulated or controlled to ensure continued function. In short, a farm manager must design, continually refine, and manage a farm system, if it is to be socio-economically sustainable.

It follows, that as a stand-alone system, management has it's own sustaining ability. Put another way, it is the ability of the farmer to continually design, refine and manage the farm system, that represents the greatest single factor determining whole-farm sustainability (the exception being catastrophic environmental disaster that management cannot accommodate). Accordingly, for a farm considered 'unsustainable' in common parlance, one might enquire if management has the ability to realise biophysical potential through appropriate production and business systems, in a way that not only fulfils a farm's unique socio-economic needs, but also protects the integrity of the underlying biophysical resource for alternative and future use.

The importance of management is often implicitly captured when sustainability is defined in terms of objectives or goals (i.e. as something for management to work towards). A popular example is that used within the Framework for Evaluation of Sustainable Land Management (FELSM) adopted by the UN Food and Agriculture Organisation (FAO) for assessing sustainability indicators (Smyth & Dumanski, 1994; Neave *et al*., 1995; Cornforth, 1998). While it is intended as a definition for sustainable land management, the objectives are more in-tune with those of farm sustainability. Objectives include:

- Be economically viable
- Be socially acceptable
- Maintain and enhance productivity
- Decrease risks to production
- Protect the potential of natural resources and prevent the degradation of soil and water quality

For the FAO at least, the farm manager must fulfil these five objectives if the farming system is to be considered sustainable. In a sense, these objectives represent a recognition that farms are subject to external pressures requiring internal responses. Implicitly, these responses include in-building a higher degree of security to decrease risk, or modifying the productivity of the system (i.e. improving efficiency) to account for social and economic change. Likewise, these responses must not impair the underlying potential of the biophysical system, and they must continue to fulfil on-farm socio-economic needs (i.e. the farm system must remain viable and acceptable in terms of returns, lifestyle, and rewards).

It is the responsibility and prerogative of the farm manager to decide how these objectives are to be specifically met as they apply to individual farms. However, it is the *ability* of the manager that largely determines whether or not they can be achieved through the appropriate design, refinement and management of a farm's production and business systems.

1.7.3 THE 'WHO' OF FARM SUSTAINABILITY

The 'who' of farm sustainability can be divided into four. Firstly, there are the *internal decision-makers* with a direct role in the function of the farm system. Management is usually the most important, but depending on the circumstances, this role can extend to include farm owners, employees, and the farm family. Internal decision-makers are characterised as having an internal influence on whether or not farm sustainability is achieved.

Secondly, *external decision-makers* influence farm sustainability in an environmental sense. They may be far-removed from the farm of interest, but their decisions and activities create opportunities and limitations that a farm may, or must, accommodate to remain sustainable. Generally, they include the agricultural industry and the government, with the classic manifestation being legislation that places constraints on farm system design and operation. As farming systems become more open, external decision-makers have an increasing influence on the autonomy of internal decision-makers – government and industry increasingly dictate how farmers farm.

Thirdly, *service providers* support internal decision-making and operation. In helping farmers, they enhance the ability of the management system to sustain the farm system. Typically, they are able to do this through specialisation, becoming knowledgeable and adept with a select dimension of farm sustainability. Veterinarians focus on animal health and production, fertiliser representatives focus on nutrient systems, land management officers focus on biophysical systems, and agronomists focus on pasture production. Farm consultants tend to orientate towards business management, but often have skills that extend into production management.

Fourthly, *stakeholders* have an interest in how farm sustainability is achieved. Although used and misused frequently within the sustainability debate, the term 'stakeholder' is interpreted here as a person with an indirect interest in the outcome of a farm decision. The analogy from which the term is taken, is a person who temporarily holds the wager or 'stake' until the outcome between two competing or gambling individuals is decided. Hence, stakeholders are not directly involved, but they have an interest in the outcome. Often stakeholders are confused with internal decision-makers when discussing sustainability at the farm level (but the term legitimately includes farmers when discussing sustainability at regional or national levels, such as the formulation of land related policy).

Historically, local community and industry have been the major stakeholders in farm sustainability. However, in recent decades other external interest groups have had an increasing influence on the ways that farms are managed. Some of the more prominent include various recreational groups, 'environmental' groups, consumer groups, and animal welfare groups. Each have their own particular interest concerning farm operation and outcomes, such as water quality, wildlife habitat, food safety, animal rights, and so on. Such concerns threaten to constrain the ways in which farms are managed, either through market forces and public pressure, or through political action and legislation.

While external decision-makers, service providers and various stakeholders all have an indirect influence on how a farm is operated, it is still the internal decision-makers who have the greatest and most direct influence. In particular, it is the internal decision-makers' worldviews that determine the way in which farm sustainability will be achieved, and as discussed, it is the ability of management that determines whether or not farm sustainability will actually be realised.

Like everyone else in society, farmers have their own personal worldviews. However, as a collective, at least three generalisations can be put forward regarding farmers' perspective on how to farm. Firstly, farmers are likely to have strongly pragmatic worldviews toward nature, meaning that if their underlying biophysical systems are to be protected, then they are most likely to be protected for utilitarian reasons. Secondly, as a necessity, conventional farmers' must orientate their views toward making a profit from their farming systems. As the saying goes, 'if you're not in business to make money, then you're not in business'. Thirdly, the New Zealand farmer is renown for his/her independence, reflecting that farmers have traditionally had an almost unassailable right to choose how they farm within their own respective boundaries (traditional property rights).

However, these strongly utilitarian, business, and independence orientated views, have been increasingly challenged as farms become more open, and thus, more dependent on externalities. Fortunately for the NZ farmer, society and government has not yet reached a point where they can justify a high degree of the control over farm design and operation. Rather, emphasis is currently directed at 'encouraging' farmers to integrate more of society's concerns into their farming operations, through ideas of advocacy, support, rewards, peer pressure, and education (Chapter 2).

1.7.4 THE 'FOR HOW LONG' OF FARM SUSTAINABILITY

Farm sustainability is not a static state, so an absolute time dimension can be difficult to ascribe. Rather, it is a dynamic state, continually being adjusted by management in response to external change. If appropriate adjustments maintain or enhance the sustainability of *all* internal systems, then the 'for how long' of farm sustainability is theoretically an indefinite period.

However, whether or not all farm internal systems are equitably maintained or enhanced is dependent on management's worldview and ability. Those interested in short-term gain (either by choice or necessity), may seek to enhance the business and production dimensions of their farm systems, often to the detriment of the biophysical system. Firstly, they may not have a land ownership responsibility (e.g. sharemikers, leaseholders), and therefore it may not be in their long-term interest to maintain or enhance the biophysical. Secondly, internal decision-makers removed from the farm operation may prioritise socio-economic gain over biophysical sustainability, such as silent partners, or those forming part of multiple ownership structures. Finally, hardship may force any farmer into the pursuit of short-term gain, in response to critical threats that may undermine economic viability and livelihood.

Enhancing socio-economic sustainability without a comparative enhancement of the biophysical must undermine the long-term sustainability of the whole farm system. Although the farm may be sustainable for an absolute timeframe, it comes as a cost to biophysical integrity (as inherent or developed integrity), and existing levels of socio-economic gain must eventually collapse or recede. If integrity is irreversibly degraded, then the long-term ability of the biophysical system to sustain alternative or future land-uses is reduced.

Reconciling socio-economic objectives with biophysical necessities is a common theme in the sustainability debate. From an agricultural perspective, it is readily achieved through various conservation and land management practices that seek to maintain or enhance the productive integrity of the biophysical system. Indeed, farmers have continued to enhance the agricultural sustaining ability of land through development since colonial times. However, agricultural utility is but one dimension of biophysical sustainability, and there is increasing pressure on farmers to recognise that their 'unit' of land is often part of larger biophysical systems that sustain more than just agriculture.

1.7.5 THE UNIQUENESS OF FARM SUSTAINABILITY

Farm sustainability has been discussed in generic terms. However, individual farms are made-up of subsystems that exhibit their own unique qualities. Firstly, biophysical systems exhibit natural variation and diversity attributable to the interaction of soils, climate, geology and topography across the New Zealand landscape (Webb & Wilson, 1995). This variation is intensified between farms with different historical developments and degradation of land (i.e. management induced variation). Secondly, farm social systems may be made up of any number of individuals, each with their own respective needs, worldviews and abilities, as determined by genetics, upbringing and experience. Thirdly, the way in-which the farm is operated will represent the interface between the biophysical and social, meaning the production and business systems will be uniquely farm-particular unto themselves.

If the make-up of each farm in New Zealand is unique, then it follows, that the sustainability of each farm will be similarly unique. Accordingly, if Kidd's (1992) suggestion of specific contextual definitions is adhered to, then each farm requires it's own respective definition of farm sustainability.

In many ways, New Zealand farms already have their own individual interpretations of farm sustainability. This is typically expressed as strategic farm planning, where the objectives set by management determine the 'what' of sustainability, and the plan outlines the 'how' and 'for how long' (as an annual plan, a five year plan, etc.). It is not usually necessary to explicitly include the 'who' and 'why' in such specific applications.

Despite farm sustainability representing the interaction of all internal systems, strategic farm plans are typically separated into those that orientate towards business, production and perhaps social objectives, and those that orientate towards biophysical conservation objectives. Early attempts to integrate the two resulted in ideas of 'conservation farming', while more recent attempts have been expressed as various ideas of whole-farm plans or sustainability plans (Chapter 6).

SUMMARY AND CONCLUSIONS

1. Principles and themes underlying the sustainability concept have been evident throughout history. Human population grows until ecological limits are approached. Adaptation through understanding and technology overcomes ecological limitations, characterised as the appropriation, modification and management of ecosystems for human purposes. Overcoming ecological limitations promotes population growth but undermines ecosystem function, both of which create self-imposed and somewhat paradoxical socio-ecological limitations that necessitate further appropriation and manipulation of ecosystems.

2. Civilisations that foresaw limits to growth developed conservation technologies and practices that allowed them to persist for periods longer than civilisations who did not. Such actions represent the seeds of modern sustainability, in that modified ecosystems were managed in a way that did not irreparably despoil, exhaust or extinguish the ability or capacity of the biophysical environment to sustain human needs over-time.

3. Humankind's ability to subvert and control nature increased dramatically during the Industrial Age, accelerating human development and population growth within nations capable of taking advantage of new science and technology. Capitalism, utilitarianism, and a growing separation between society and nature, contributed to largely unconstrained expansion and development, and an associated widespread degradation of nature and natural resources.

4. Initial backlash against industrialisation introduced ecocentric orientated views regarding conservation or protection of nature and natural resources. Such views affirmed that nature has intrinsic value beyond it's utility value. Similar views were periodically expressed by naturalists and botanists throughout the 19th century, alongside utilitarian views that advocate practical anthropocentric reasons for conservation.

5. Conservation of natural resources gained widespread support in 1900s America, with the emergence of the Conservation Movement. While initially orientated towards wildlife and forestry, it soon expanded to include agriculture with the soil conservation movement of the 1930s. The Movement was notably utilitarian in it's conservation approach, but became more idealistic and ecocentric towards the mid-1900s.

6. Strongly ecocentric and idealistic views came to the fore during the environmental movement of the 1960s and 1970s. Pollution was a dominant theme throughout, along with a series of 'doomsday' forecasts that predicted unchanged patterns of living and development would lead to global disaster. Issues concerning the human/nature relation were popularised through the parallel growth in communications, trade, and other expressions of globalisation. Deep ecology and 'back to basics' thinking were two alternative development philosophies that gained widespread support.

7. Sustainability as a stand-alone concept also emerged during the 1970s, firstly as an incidental term in various human/nature orientated publications, and then secondly as a guiding principle for international development by the United Nations.

8. Widespread recognition of the concept was forthcoming during the early 1980s, spurred in part by a series of international ecological disasters and the 'second wave of environmentalism'. *The World Conservation Strategy* introduced the concept of 'sustainable development', which was subsequently picked-up by the Brundtland Commission who popularised and structured the concept in their influential publication, *Our Common Future*. This report guided future debate regarding the concept, and helped elevate it onto the

international political agenda. Sustainable development was defined in such a way that both developed and developing nations could agree to adopt it as the principle guiding future human development.

9. Popularity for the sustainability concept peaked in the 1990s with the first Earth Summit held in Rio de Janeiro, 1992. It was during the three-year build-up to the Summit that the concept was disseminated throughout the world, involving the participation of stakeholders down to the grassroots level. Several 'earth summit agreements' emerged from the Summit, the most important of which was *Agenda 21* as it represented the international community's collective 'action plan' toward achieving sustainable development.

10. Although being consolidated during the early 1990s, popularity for the concept declined after the Summit. This became apparent at the next Earth Summit (New York, 1997), during which many nations reported difficulties in implementing the principle, and some outright reneged on agreements made during the first Summit. This was reaffirmed at the third Summit (Johannesburg, 2002), where 'development' appeared to have gained ascendance over 'sustainable development'.

11. Despite a decline in popularity, the sustainability concept is unlikely to go away. As a guiding principle, it has been embedded in development policy, legislation and agreements around the world.

12. Part of sustainability's popularity has been attributed to it's vagueness, allowing divergent views and ideas to come together as one conceptual framework. Vagueness has also allowed the concept to be applied to virtually any application with a dimension of continuity, giving rise to hundreds of conflicting and confusing definitions. Further, lack of an overarching definition has allowed the concept to be skewed toward institutional and group prerogatives, and misappropriated by those wishing to link sustainability with an issue or context that could benefit from the environmental morality that the concept tends to convey.

13. Sustainability is highly amendable to a diversity of applications because, abstractly, virtually any system can sustain one or more systems. Irrespective of whether or not the system is economic, social, biophysical, or even metaphysical, the flow of energy, material or information from one system to the next is characterised by one system having an ability to sustain (a state), while the follow-on system is sustained (a process).

14. From a systems perspective, one or many systems can have an ability to sustain one or many systems over-time. Such relations are sequential, as one system sustaining another system, which sustains another system, and so on. Sequential relations can be linear or cyclic, or in the case of complex adaptive systems, they can be expressed as a dynamically complex interaction of multiple systems and relations constantly adjusting in response to environmental change. The complex and dynamic nature of many of the world's systems continue to defy understanding by science.

15. Much of the confusion regarding applications of sustainability can be reduced by acknowledging the concept's flexibility, and then explicitly stating the context in which it is being used. Criteria useful for seeking to clarify contextual applications include:

    a. *The 'what' of sustainability* describes the central system of interest.

    b. *The 'why' of sustainability*. In a systems perspective this describes the follow-on system(s) being sustained. In conventional terms, it describes the purpose of the sustaining relation.

    c. *The 'how' of sustainability* describes the relation or relations sustaining the central system of interest (i.e. what sustains the ability to sustain).

d. *The 'who' of sustainability* is a recognition that people increasingly decide the what, how, why and for how long of sustainability in managed systems. Hence, the worldviews of decision-makers can influence how sustainability is interpreted.

e. *The 'for how long' of sustainability* is of critical importance in the sustainability debate. Even if a system is degraded over-time, it is still exhibiting an ability to sustain other systems, albeit for an absolute timeframe. All systems eventually degrade as dictated by fundamental thermodynamic laws, but this is often obscured by the dynamic complexity of real-world systems, and our own relative perception of system longevity. Systems that we cannot qualify with an absolute temporal dimension are typically considered 'indefinite', such as the open-ended 'for present and future generations' used to describe continued human development in many sustainability interpretations.

f. The contextual *hierarchy* at which the concept is being applied. This is a recognition that sustainability can be applied in a similar context, but at different levels of generality. As an example, an interpretation of sustainable land management needs to be generalised for developing regional and national policy, but it needs to be specific for application at the farm level.

Although each criterion can rarely be clarified in it's entirety, together they have value towards reducing some of the confusion surrounding contextual applications of the sustainability concept.

16. Systems are a dimensionless concept, meaning system sustainability can be interpreted in both internal and external contexts. In an external sense, a farm is sustained by inflows of information, material inputs and energy, and produces various outputs that contribute to sustaining rural economies, markets, society's food and fibre requirements, and so on. Internally, a farm has five principle systems that can be ordered as the *biophysical system* sustaining the *production system*, which sustains the *economic system* so it may sustain the farm's *social system*. Reverse sustaining relations are also apparent, particularly through the *management system* that transverses all farm-internal systems to control and regulate farm function. In this sense, management is a cybernetic system with it's own abilities, thusly adding a degree of self-sustainability to the farm system.

17. Although every farm subsystem and sustaining relation is important, the sustainability of the biophysical, environmental, and management systems is of critical importance.

    a. The biophysical provides an inherent ability to sustain that differs between farms (land capability), and represents the base upon which the rest of the farm is designed around.

    b. External change drives internal adjustment of the farm system. Environmental fluctuations create opportunities and limitations that a farm may, or must, accommodate if it is to remain sustainable.

    c. It is the prerogative and responsibility of management to adjust to change, through designing, refining and managing the farm system. Management's worldview influences the way in which this can be achieved, while their ability determines whether or not it is actually achieved.

18. Farm sustainability requires compromise. Each principle system must be sustained equitably, which may create a degree of conflict. Put another way, objectives pertaining to different dimensions of farm sustainability must be reconciled.

19. Farm sustainability is complex and dynamic, and is likely to become more so in the future. Farm systems are becoming more open, subjecting them to increased pressure from various interest groups. Restrictions on how farms are designed and operated continue to increase. External market, logistic, economic, and

communication systems are evermore complex and dynamic. Farmers have access to an almost bewildering range of information and technology. Long-term trends push commodity prices down, while costs of living and farm inputs continues to increase. Internally, needs of the farm social unit continue to change as they seek standards of living comparable to the rest of society. Hence, achieving farm sustainability can be difficult, and is likely to become even more challenging in the future.

20. Farmers have exhibited two principle responses to the difficulty of reconciling multiple sustainability objectives, and the increasing complexity of farm sustainability. Part or whole diversification of the production system into alternative policies, land uses, or farming philosophies (e.g. organics) has enhanced the sustainability of some farms. However, the dominant response appears to be continual intensification of conventional production systems, through the pursuit of productivity (efficiency) gains.

21. Each farm in New Zealand is biophysically and socio-economically unique. As production represents the interface between the two, production systems are similarly unique. Accordingly, what is considered sustainable will differ between farms. It follows, that each farm in New Zealand requires it's own interpretation of sustainability, provided it falls within the generalities of higher tier sustainability definitions. In many ways, this is already undertaken through strategic farm planning, although rarely do farm plans seek to integrate business and production plans with biophysically orientated conservation plans.

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Chapter 2

NEW ZEALAND REGIONAL AUTHORITIES AND THE PROMOTION OF SUSTAINABLE LAND MANAGEMENT

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INTRODUCTION

The imperative to use and manage resources sustainably was recognised by New Zealand as a nation over ten years ago, and captured as legislation known as the Resource Management Act (RMA). The purpose of this Act is to promote the sustainable management of natural and physical resources (Part II; Section 5, RMA, 1991). Considerable responsibility for implementing the Act is devolved to regional authorities (RAs), who are required to interpret and apply the RMA's sustainability principles within their own regional jurisdictions (Memon, 1991). This is largely an autonomous process, which has resulted in the formulation of regionally-unique policy, plans, and approaches for promoting sustainable resource management (SRM).

Knowing how New Zealand's RAs are endeavouring to promote SRM has important implications towards farm sustainability. RAs are required to promote SRM for the common good, which often conflicts with why agricultural resources are managed for the good of individuals and the farming community. Because the RMA can convey considerable regulatory and coercive powers (but dependent on justification and resourcing), RAs can have a strong determining influence on the what, why and how of resource management within farm sustainability. Farm resources of land, water and natural features (*e.g.* wetlands, bush remnants) receive particular attention, often expressed collectively as Sustainable Land Management (SLM).

Identifying how all RAs are promoting the SLM dimension of SRM can be difficult. Firstly, documentation describing how RAs intend to promote SRM is substantial. This includes 16 *regional policy statements* (RPS), approximately 42 SLM-related *regional plans* (excluding standalone plans for coast, air, transport, etc.), and a diverse range of regional strategies. A detailed (or even casual) analysis of all these documents would be time-consuming and disproportionate to this thesis. Secondly, many regional plans are still in the draft or proposal stage. While a proposed/draft plan may outline an authority's desired method of promoting SLM, this does not necessarily mean the desired method will be legally permissible. Thirdly, policy and plans may not represent how RAs are actually promoting SLM. Internal dysfunction, misinterpretation, lack of communication and lack of resources, may all contribute to discrepancies between intended policy and the actual implementation of policy.

This chapter reports on a study aimed at identifying how different regional authorities are attempting to promote and effect the sustainable management of farm-land throughout New Zealand. It begins with a brief review of New Zealand's SRM and SLM administrative framework, and then presents and discusses results from a nationwide survey. This survey involved interviewing representatives from each of NZ's 16 RAs, and asking them to describe their council's present and future use of policy instruments relating to SLM.

A range of policy instruments are available to RAs for translating SLM policies into action. Several instruments receive consistent use across all authorities, although the degree of use varies widely. Likewise, the degree of emphasis afforded to some instruments notably distinguishes several RAs as having somewhat antithetical political philosophies regarding the most efficacious means of promoting SLM. Overall, most RAs exhibit a tendency towards non-regulatory approaches, although a small number of councils are constrained towards a regulatory emphasis. Over the long term, farmers may be faced with a greater overall shift to regulatory approaches, if they fail to significantly progress the SLM dimension of their farming operations.

NEW ZEALAND'S SRM & SLM FRAMEWORK

New Zealand's efforts towards sustainable resource management are structured under the Resource Management Act (1991). This legislation not only defines SRM and the conditions of resource use, but it also provides an administrative framework for implementation and monitoring. This framework devolves much of the management responsibility down to local authorities, who are required to develop their own particular policy and plans.

Central and local government also support and encourage independent SRM related initiatives. These may be fostered by communities, industry, or other non-government organisations (NGOs), including recreation and environmental groups. Support may be financial or service related, and can often include a research dimension. Taken together, all of New Zealand's efforts toward SRM are coordinated through the Environment 2010 Strategy, while efforts relating specifically to the sustainable management of land are guided by the SLM Strategy.

2.1. The RMA and Sustainable Management of Resources

Prior to the 1990s, laws relating to resource management (RM) in NZ were numerous, cumbersome, and poorly interrelated (MfE, 1997). Almost 60 different Acts were in place, many of which focused almost myopically on their own targeted RM issues. Implementation responsibilities were fragmented between a variety of government institutions, some of which had dichotomous functions of both exploiting and protecting natural resources (*e.g.* the NZ Forest Service was required to protect indigenous forest, while also having to develop indigenous forest into commercial forestry plantations). In short, NZ's RM system lacked a level of coordination, integration and consistency, that would be necessary for the emerging challenge of sustainable resource management.

NZ's RM Legislation was subject to a 3-4 year review as part of the 1980 state sector reforms. This was announced in December 1987, and continued through until October 1991 when the all-encompassing Resource Management Act was introduced. This new Act would have the single overarching purpose of promoting the sustainable management of natural and physical resources (Figure 2.1), and would simultaneously seek to cover the use, development and protection of all New Zealand's land, air and water resources in an integrated manner (the partial exception being the management of mineral and fishery resources).

> *(1) The purpose of this Act is to promote the sustainable management of natural and physical resources*
>
> *(2) In this Act, 'sustainable management' means managing the use, development, and protection of natural and physical resources in a way, or at a rate, which enables people and communities to provide for their social, economic, and cultural well being and for their health and safety while -*
>
> *(a) Sustaining the potential of natural and physical resources (excluding minerals) to meet the reasonably foreseeable needs of future generations; and*
>
> *(b) Safeguarding the life-supporting capacity of air, water, soil, and ecosystems; and*
>
> *(c) Avoiding, remedying, or mitigating any adverse effects of activities on the environment*
>
> (Part II; Section 5, RMA 1991)

Figure 2.1: The Resource Management Act's stated purpose and definition of sustainable management.

The RMA is a lengthy statute, comprising 15 main Parts divided into 430 Sections. It embodies a number of RM themes and features, many of which have been described as 'radical', 'unique' and 'innovative' (Blunden *et al.*, 1996; Bettjeman, 1997; Frieder, 1998). Some of the more outstanding include:

- A focus on the effects of RM activities, rather than seeking to prescriptively control the activity itself (which was a feature of previous RM legislation). As an example, instead of providing a list of activities deemed legal or illegal, the RMA requires people to apply for permission (as a 'resource consent') to undertake a particular activity. This includes any activity involving the use or development of a natural or physical resource, and/or any activity that affects the environment in some way for a stated period. It is up to the applicant to prove that the activity does not unnecessarily compromise environmental quality or resource integrity.

- Considerable provision for the inclusion of cultural and community input. This is captured as two principles: *that decisions on environmental matters are most appropriately made by the communities directly affected by those decisions*; and *that community participation is vital to effective resource management* (MfE, 1999). In practice, this means that any person has a right to express their views during most RM decision-making processes, particularly in regard to the preparation of local government policy and plans, and the application process of notified resource consents. Maori community receives special attention, in that all decisions under the Act must take into account or consider the Treaty of Waitangi; Maori culture & stewardship ethic (kaitiakitanga); and Maori communities must be consulted during the development of local government policy and plans.

- An all pervading emphasis on *sustainable management* of resources (to be discussed).

- A framework that decentralises and transfers implementation responsibilities from central government down to local government (to be discussed).

- A precautionary approach to decision-making (to be discussed).

- Encouragement of policy instruments other than just regulation (to be discussed).

Additionally, the RMA has three conceptually separate but related functions (MfE, 1997). Firstly, it allocates access to, and use of 'common property' natural resources, such as groundwater, geothermal energy, rivers and coastal foreshores. Secondly, it places controls on the discharge of contaminants to air, land and water (*i.e.* pollution), and thirdly, it seeks to manage the adverse effects of human activities. In this sense, the RMA places 'environmental limits' on how resources can be used (Bettjeman, 1997), by specifying a series of duties, restrictions and responsibilities. As an example, every New Zealander has a *duty* to avoid, remedy or mitigate any adverse effect on the environment[1].

[1] The term 'environment' is defined in the RMA to include ecosystems, society as a part of ecosystems, all natural & physical resources, 'amenity value', and socio-economic 'conditions' that affect the other components of environment (RMA, Part 1: Section 2). As noted by McShane (1998) this definition includes 'just about everything' (p.49).

2.1.1 SUSTAINABLE MANAGEMENT OF RESOURCES

The RMA is not New Zealand's only environmental legislation, nor is it the only Act to integrate sustainability as it's ultimate guiding principle. However, it is the foremost statute controlling the use of the majority of resources in this country, and it was certainly New Zealand's first attempt to explicitly develop law according to the sustainability concept. Indeed, Smith (1993) goes as far as claiming that New Zealand's inclusion of sustainability in the RMA was actually a world first.

The RMA integrates the concept of sustainability as 'sustainable management' of resources, or for the purposes of this discussion, 'sustainable resource management'. This is appropriately defined at a national hierarchical tier (previous Figure 2.1), making it broad and generalised, and thus suitable for more detailed interpretation at different spatial scales (*e.g.* regional, district, community, farm) and for individual resource types (*i.e.* land, air and water). It has been derived the WCED's (World Commission on Environment & Development, 1987) definition of sustainable development, but tends to focus more towards the biophysical/ecological/environmental dimensions of sustainability. Social and economic dimensions are left to other mechanisms (*e.g.* welfare, taxation, social services, the economy, etc.), although the process of controlling resource allocation and use includes strong social, economic and cultural elements (*e.g.* community participation in decision-making, user pays, polluter pays).

The RMA's definition of sustainable management is strongly anthropocentric, but parts could be interpreted as being ecocentric. Firstly, resources are to be managed in a way that allows society to sustain an undefined level of well-being, both now and in the future. Secondly, the 'potential' of resources is to be sustained for the undefined needs of future generations, while thirdly, the ability of the environment to support basic life-supporting needs is to be 'safeguarded'. Coupled with avoiding, remedying or mitigating adverse environmental impacts, safe-guarding the environmental ability to support life implies an ecocentric dimension (*i.e.* ability to support *all* life is to be safe-guarded).

Reinterpreted against the model discussed in Chapter 1, SRM is concerned with the ability of an interventional system of management to sustain human needs (through the use and development of resources), resource integrity (conservation of resources for future use), and environmental quality (protection). Hence, the 'what' of sustainability is people, resources and environment (*i.e.* what is being sustained), while the 'why' is New Zealanders and their needs, and perhaps other forms of non-human life (although there are other Acts that deal explicitly with flora and fauna protection). The 'for how long' is obscurely given as the standard 'for future generations', and the 'who' includes all New Zealanders (as resource using decision-makers and administrative decision-makers). The RMA provides the 'how', as a prescribed system of structuring and controlling New Zealand's management of resources.

2.1.2 ADMINISTRATION & IMPLEMENTATION FRAMEWORK

Another dimension of the 1980s state-sector reforms was the restructuring of central and local government organisation and responsibilities. As compared to the sporadic and fragmented emergence of pre-1980s legislation and government organisation, the relatively condensed reform period allowed many of the new changes to be integrated in manner that was more complementary than before. This is particularly apparent with the Local Government Act (LGA) of 1987 and it's interconnections with the RMA.

Under the LGA, the pre-1987 structure of 625 individual boards, authorities, counties, municipalities, districts and united councils, has been simplified down to 16 *regional authorities* (RAs) and 69 *territorial authorities* (TAs). TAs include 14 *city councils* and 55 *district councils*, while RAs include 12 *regional councils* and 4 *unitary councils*. Each type of council has administrative responsibilities toward their own respective geographical regions, districts, and cities. Regional boundaries have been defined mostly according to natural river catchments (Figure 2.2), while district boundaries are defined according to infrastructure and it's management (district boundaries do not necessarily conform to regional boundaries). Unitary councils have combined responsibilities as both TAs and RAs.

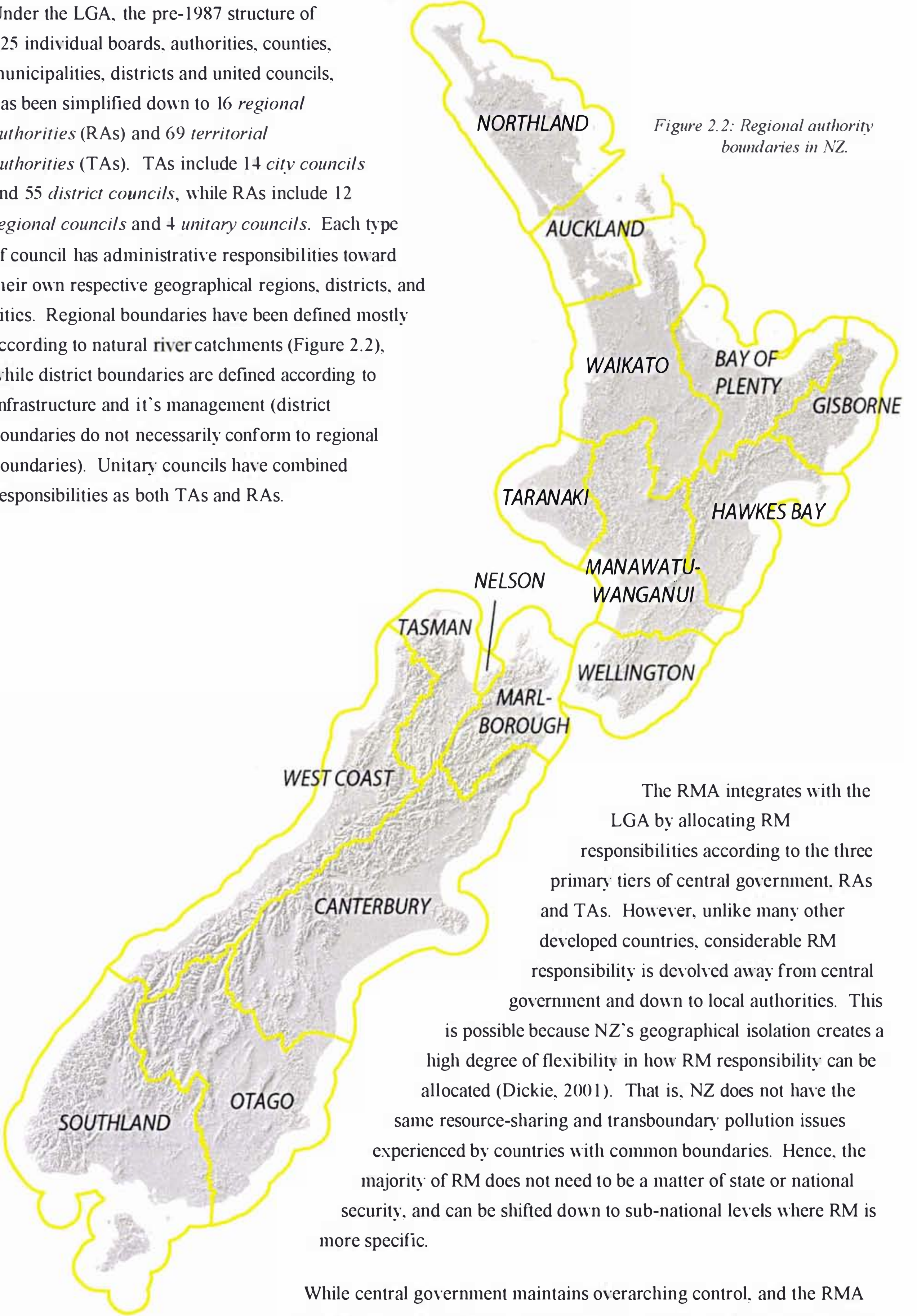

Figure 2.2: Regional authority boundaries in NZ.

The RMA integrates with the LGA by allocating RM responsibilities according to the three primary tiers of central government, RAs and TAs. However, unlike many other developed countries, considerable RM responsibility is devolved away from central government and down to local authorities. This is possible because NZ's geographical isolation creates a high degree of flexibility in how RM responsibility can be allocated (Dickie, 2001). That is, NZ does not have the same resource-sharing and transboundary pollution issues experienced by countries with common boundaries. Hence, the majority of RM does not need to be a matter of state or national security, and can be shifted down to sub-national levels where RM is more specific.

While central government maintains overarching control, and the RMA provides for five matters of national importance (RMA; Section 6), by far the majority of RM responsibility in NZ is devolved to TAs and RAs.

2.1.2.1 Central government responsibilities

A number of ministries have RM responsibilities under different sets of legislation. The Ministry for the Environment (MfE) has the most responsibility under the RMA, according to a number of stipulated functions (Figure 2.3). The most important of these is the requirement to prepare *national policy statements* and *environmental standards & guidelines*. National policy statements provide a responsive means of addressing RM issues that affect the whole country, or issues that require a nationally coordinated response as the most effective solution. Local authorities are required to work within national policy statements (RMA; Section 55).

Environmental standards and guidelines represent the upper and lower thresholds of environmental quality deemed acceptable under SRM. *Guidelines* are non-binding recommendations regarding procedures for developing, implementing and monitoring a local government system of environmental quality assessment. In contrast, legally enforceable *standards* represent binding conditions that must be recognised in the process of using, or allocating use of, natural and physical resources.

MINISTRY FOR THE ENVIRONMENT FUNCTIONS

1) *To prepare national policy statements*
2) *To make regulations giving environmental standards*
3) *To monitor environmental standards*
4) *To use 'call-in' procedures*
5) *The approval of heritage protection authorities*
6) *The making of water conservation orders*
7) *The approval of network utilities operators*
8) *To consider the 'user pays' dimension of the RMA*

Figure 2.3: Primary functions of MfE under the RMA (adapted from Curham, 1992).

2.1.2.2 Territorial authority responsibilities

Under the RMA, TAs are charged with the overarching responsibility of achieving 'integrated management of the *effects of the use, development, or protection* of land and associated natural and physical resources of the district' (MfE, 1997). This responsibility orientates toward local infrastructure and services, particularly in regard to the control of subdivision, noise, and impacts on land and surface waters (Figure 2.4). TAs are required to fulfil these responsibilities by preparing district plans, issuing resource consents, taking enforcement action, and by monitoring both the state of the environment (SoE) and the effects of their own decisions (MfE, 1999).

In conjunction with the LGA, territorial authorities also have responsibilities for water supply, land development, managing parks & reserves, some transport, sewage and storm-water drainage, and other similar public works.

TERRITORIAL AUTHORITY RESPONSIBILITIES

1) *To set objectives, policies & methods for the integrated management of the effects of the use, development & protection of land & associated natural & physical resources*
2) *Control of the effects of the use, development & protection of land*
3) *Control of subdivision*
4) *Control of noise*
5) *Implementation of Rules for natural hazards & hazardous substances*
6) *Control of the effects of surface activities on lakes & rivers*

Figure 2.4: Territorial Authority responsibilities under the RMA (adapted from Curham, 1992).

2.1.2.3 Regional authority responsibilities

RAs are afforded the most responsibility under the RMA, expressly to achieve the integrated management of natural and physical resources across their extensive regions. They are given 'primary responsibility' for the management of most biophysical resources (Figure 2.5), particularly in regard to managing the quality and quantity of fresh water, soil conservation, and the discharge of contaminants (pollutants). They must also manage activities that impact on coastal marine areas (alongside the Department of Conservation), for which they are required to prepare a *regional coastal plan*. They also have functions relating to civil defence, drainage, and the management or control of pests and weeds.

REGIONAL AUTHORITY RESPONSIBILITIES

1) To set objectives (policy statement) for integrated management of the natural & physical resources of the region
2) Primary responsibility for the management of water, soil & geothermal resources
3) Mitigation of natural hazards
4) Responsible for pollution - the discharge of contaminants to land, air & water
5) Control of the introduction of plants into the beds of freshwater bodies for certain purposes
6) Management of coasts

Figure 2.5: Regional Authority responsibilities under the RMA (adapted from Curham, 1992).

Along with coastal plans, RAs are required to spell-out their RM objectives in *regional policy statements* (RPS). These statements consider issues of regional significance, the regional community's environmental goals, and outline actual policy regarding the management of air, land and water. Regional councils may also prepare *regional plans* for these and other resources, although this is not mandatory. However, if a council is to develop it's own *rules* (regulatory conditions of local resource use), then these rules must be contained within a regional plan. All of NZ's regional councils have opted to prepare regional plans, while unitary councils may integrate this regional dimension into their *district plans*.

Forthcoming policy and plans must be consistent with central government directives such as national policy statements. They must also adhere to the principles and guidelines laid down in the RMA, including the somewhat unconventional (*cf.* to most other types of legislation) requirement of RAs to assess non-regulatory means of bringing about their desired RM objectives and policies.

2.1.3 PRECAUTIONARY APPROACH

The RMA recognises that human activities can adversely impact on the integrity and value of resources (*i.e.* RMA: Section 5). Such impacts are to be managed as effects, through the three management options of avoidance, remediation, or mitigation (RMA: Section 17). Choosing the most appropriate option for a given activity (*i.e.* one that is equitable and fair, while at the same time having the least practicable impact on resource and environmental quality), requires a sound understanding of the effects that may associate with that activity.

We can never have complete understanding. As discussed in Chapter 1, we are far from fully understanding the dynamic complexity of environmental systems, particularly those with a biological component. Likewise, we cannot predict the future with absolute certainty. In short, we can never really be 100% sure about what the long-term consequences of our actions or activities may be. This predicament is often expressed as having incomplete information.

RM decision-making does not cease in the absence of understanding or information. Rather, decisions are made according to available information, in conjunction with a consideration of risk. That is, the potential benefits of a decision (*e.g.* increased well-being, health or safety) are weighed against potential undesirable consequences (*e.g.* resource depletion, biodiversity loss, etc.). A decision-making process that seeks to minimise the risk of undesirable consequences is said to be precautionary.

A precautionary approach to RM decision-making can be described as taking all practicable and reasonable steps to ensure decisions are sound and responsible. Put another way, available information must be considered, potential risks should be evaluated, and then the final decision should be based on a level of risk deemed acceptable. Because an 'acceptable level of risk' can vary widely between individuals, the RMA suggests a conservative approach to RM, whereby the risk of adverse effects is to be minimised (principally) for the good of the community and future generations.

Many RAs explicitly state a precautionary approach to RM decision-making in their regional policy statements, particularly as it relates to the consent process. If an activity is well-understood then it is afforded the status of *permitted*, *prohibited* or *controlled*, while activities associated with incomplete understanding are assessed on a case-by-case basis as *discretionary* or *non-complying* activities. In doing so, RAs seek to minimise the risk of adverse environmental effects when information is limiting.

2.1.4 THE SECTION 32 TOOLBOX

Under Section 32 of the RMA, local authorities (and central government) are strictly required to examine in detail, and justify, the way in which they intend to promote sustainable management within their respective jurisdictions. A key *duty* involved in this process, is the identification and consideration of alternative means – other than just regulation – through which RAs and other administrative decision-makers can bring-about their intended RM outcomes. Along with regulation, these 'alternative means' are regarded here as *policy instruments*.

Policy instruments represent approaches and tools through which RAs and other government decision-makers, can bring into effect (implement) their intended RM actions (objectives, policy and plans). In this sense, policy instruments represent the interface between desired and actual RM outcomes (the proverbial 'coalface'), and can therefore have a large determining influence on the effectiveness of official efforts to promote sustainable management.

2.1.4.1 Why consider alternatives?

RAs can theoretically elicit considerable regulatory powers from the RMA, depending on their interpretation and justification. However, although being a powerful tool unto itself, regulation is not necessarily the best means of inducing widespread change in the way resources are managed (McShane, 1998; Morriss, 1998). Along with the common regulatory questions of fairness and democracy, the effectiveness of enforcing SRM is limited by:

- The high cost of monitoring or policing the activities and environmental impacts of individual resource users.

- The fairness of user pays for community benefit. An example is upstream soil conservation for the benefit of downstream communities. Although benefits may be mutual, is it fair for the resource user to bear the entire cost of SRM, particularly if changes in RM have been forced through regulation?

- A lack of information. RAs are required to justify their use of regulation, often formally within the Environment Court. It can be difficult and/or expensive to obtain some types of environmental information.

- Change takes time. Sustainability under the RMA introduces a somewhat radical readjustment in how RM is viewed and carried out. Traditional rights of resource-users are challenged (particularly property rights), and traditional systems of resource-use require modification. For farmers, the right to use their land as they see fit is diminished, while systems of land-use built-up over years of trial and error may require re-evaluation and major adjustment in the way they function. Using regulation to fully implement the RMA over a short period may be possible, but the required rate of change would probably result in considerable resistance from resource users and/or dysfunction in their systems of resource use.

2.1.4.2 What are the alternatives?

A wide array of conceivable policy instruments exist. All, in some manner, seek to overcome the fundamental reasons as to why people don't adopt the views, behaviours or practices, considered important to other people. In the field of RM, these reasons are often negatively regarded as *impediments, barriers* or *constraints* to adoption or change (*e.g.* Rauniyar & Parker, 1998; Rhodes *et al.*, 2000), on the assumption that one group of people have better ways of managing resources than another group of people. From another perspective, they can be regarded as defences against change or checks against unwanted progress.

At its most simplistic, people will not adopt because of differences in awareness, motivation, ability and beliefs. Put another way, they cannot adopt that which they don't know about (awareness), they may not want to adopt (motivation), or they may not have the skills, knowledge or resources necessary for adoption (ability). Likewise, they may not believe adoption is necessary or possible (beliefs). Any one of these factors can represent the principal reason why a resource-user may resist adoption, or conversely, the reason may be a combination of factors that reflects the complexity of individual RM situations and personal abilities.

At a wholly theoretical level, policy instruments used by RAs should match the reasons why resource-users don't adopt SRM (Figure 2.6). If they didn't match, then constraints would not be addressed or overcome, and RA efforts to promote SRM would therefore be ineffective.

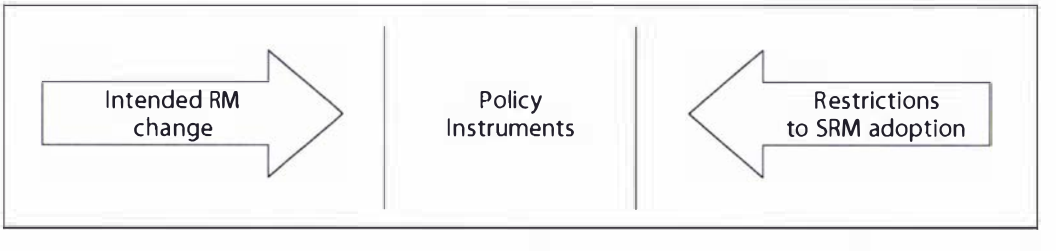

Figure 2.6: Policy instruments represent the means through which SRM intentions are implemented. Logically, policy instruments can only be effective if they address the reasons why resource-users resist compelled change.

In this sense, it is feasible to suggest that policy instruments can be categorised according to the constraints they most closely associate with. However, this is only possible in some cases, as instruments often overlap in the types of constraints they aim to address. Financial grants are one example, as they can be regarded both as an incentive to motivate, and as a resource to enable change. Likewise, a number of policy instruments can be complexed together as SRM or SLM programmes, many of which aim to simultaneously address a broad range of conceivable constraints.

The range of policy instruments used to investigate how RAs are effecting their SLM policy have been drawn from a number of sources (including Morriss, 1998; Sapsford, 1998 & 1999; Kneebone *et al.*, 2000; MfE, 2000b). Specific instruments, definitions and related delivery/extension methods are presented in Appendix II. Broadly grouped, they include regulation, economic instruments, bargaining instruments, participatory processes, education, advocacy, and assistance services.

2.1.4.2.1 Regulatory instruments

Regulatory instruments are those used to enforce the RMA's principles and guidelines. An authority may erect a *rule* within a district or regional plan, which places restrictions on a local resource use and/or environmental impact. Rules are typically linked to *consents*, which can be interpreted as sanctioned permission to undertake an activity. Other regulatory instruments include:

- *Abatement notices* requiring nuisances to be fixed or actions taken, or ceased, to ensure compliance (RMA; Section 322).
- *Infringement notices* that impose a nominal fine on resource users who offend against the Act (RMA; Section 343C).
- The threat of prosecution if an offence is committed against the Act, or against a rule, standard, or any other legal requirement. Under the Act, a serious offender could be jailed for up to two years, or face a maximum fine of $200,000. A further $10,000 per day may be imposed if the offence continues unabated.
- Every person, including local authorities, can apply to the Environment Court for an *enforcement order* that can halt an activity, ensure compliance, or avoid adverse effects (RMA; Section 314).
- Special regulatory instruments include a *direction* to control water use during times of shortage (RMA; Section 329); *excessive noise directions* (RMA; Section 327); and powers to enter any place to undertake *emergency works* to prevent adverse environmental impacts (RMA; Section 330).

2.1.4.2.2 Economic instruments

Economic instruments involve some form of financial provision or penalty. Providing finances as grants, subsidies or rewards, can represent a means to encourage change (as incentives to motivate) and/or a means of enabling change if money is a constraining resource. Charges, weighted fee structures, rates relief, and rating differentials can all be used to encourage desirable activities and discourage undesirable ones, while refund or reimbursement schemes can be used to encourage completion or compliance. Outright financial penalties (see regulation above) can both discourage (*i.e.* as a potential penalty) and punish. Bargaining type instruments may also involve an economic dimension, such as 'bundling' many resource consents within a single application procedure to reduce costs.

2.1.4.2.3 Bargaining instruments

Bargaining instruments involve some form of negotiated agreement between resource users and those seeking to promote SRM. While many types of agreement are conceptually possible, only four are discussed here:

- *Covenants* involve an agreement between resource owners (namely land owners) and an administering organisation, regarding the protection of a privately owned resource for an extended period. The most common is the *open space covenant* promoted and administered by the Queen Elizabeth II National Trust. This type of covenant involves a legal agreement between a land owner and the Trust, over the protection of an open space feature (often fragments of indigenous forest) into perpetuity.

- *Management agreements.* These represent an agreement between SRM promoters and individual resource owners, to manage a given resource in a certain way (Sapsford, 1998). They differ from covenants in that the agreement must be renegotiated when resource ownership changes. An example is the 'land improvement agreements' traditionally used in soil conservation under the Soil Conservation and Rivers Control Act (1941).

- *Consent bundles* essentially represent long-term planning for resource consent. The process involves the collaborative identification of possible resource consents that may be required by a resource user over a defined period, and then 'bundling' them together within one application procedure (Witte, 1999). Advantages include reduced costs and time delays, increased RM security and confidence, and a reduction in the *ad hoc* way consents are typically issued.

- *Entitlement and obligation bundles*, whereby certain rights and entitlements (particularly property rights) are negotiated against certain RM obligations, to produce a paired or bundled set of rights and duties. If these 'bundles' are transferable between parties, then they are regarded as *tradable rights* or *tradable permits* (Sapsford, 1998).

- *Participatory agreements* between community groups and RAs. For any given community-group initiative that aligns with SRM policy, a RA may agree to provide funding and technical support while (often implicitly) the group agrees to provide the labour, organisation and design.

2.1.4.2.4 Participatory processes

Participatory processes link closely with bargaining, education and advocacy type instruments. Morriss (1998) defines them as 'processes that enable information sharing and learning' (p.21), which can be expanded to include collaborative processes where two or more parties continuously work together towards a common goal. Examples include various care-groups, such as those promoted by Landcare Trust. Field days, focus farms, discussion groups and other forms of extension may also be included if they involve a high degree of interaction, participation, or action research.

2.1.4.2.5 Education as an instrument

At it's purest, education is the most moral means of achieving induced change. In one sense, it involves provision of 'the facts' as information or demonstration, and then leaves it to a person or group to decide on the most responsible method of managing resources. This is typically achieved through information sheets, field-days, focus farms, discussion groups, and other forms of extension and technology transfer. In terms of constraints, such information can help increase awareness, perhaps motivate, and increase ability (as knowing how to change).

More interactive forms of education include teaching and training. Teaching is conducive towards the process of understanding, while training implies the development of skills. Applied in an adult education and resource management sense, teaching and training seeks to develop the ability of resource-users to manage their resources more sustainably.

The downside of education is a slow rate of change, and an unattractiveness to those disinterested in structured learning (*i.e.* a slow rate of uptake). Likewise, the premise that education will lead to desirable change relies on an assumption that people are rational, and that the educator has all the necessary facts upon which a sound decision can be based (much is still unknown about biophysical and ecological processes as they relate to resource and environmental management). Further, and perhaps most importantly, education can be intentionally or unintentionally biased toward institutional prerogatives, particularly through the selective use of facts and skewed emphasis. In this context, education can be heavily, and perhaps immorally, loaded with advocacy (see below).

2.1.4.2.6 Technical assistance as an instrument

This involves the provision of technical services to help people manage their resources. It specifically targets the management ability of people as a constraint, which is overcome through using the abilities of a specialist. Soil conservation planning is a classic example, whereby the environmental management-abilities of farmers are supplemented by those of specialist soil conservators.

2.1.4.2.7 Advocacy as an instrument

To advocate is defined as defending or promoting a cause (Cassell, 1994). As such, advocacy is a component of all other instruments by definition, as they all involve the fostering of one party's preferred views, behaviours or practices, onto another party. It may also be used independently from other instruments, particularly through demonstration and promotion, such as field days, promotional information, or simply by pleading one's cause on a one-to-one basis.

2.1.4.2.8 Other instruments

MfE (2000) list four additional policy instruments. *Research* along with *monitoring* are regarded as instruments, perhaps either as means to obtain and provide information for education, or to justify the use of regulation. *Land purchase* is a specific and potentially expensive instrument. Lastly, and as an antithesis to active SRM promotion, '*doing nothing*' is regarded as a valid policy instrument.

2.1.5 CENTRAL GOVERNMENT FUNDING TO PROMOTE SRM & RESEARCH

Central government in NZ supports SRM related research and non-government initiated projects that aim to further SRM in some manner. Primary funding sources include the Public Good Science & Technology funds (PGS&T) administered by the Foundation of Science, Research & Technology (FoRST), the Sustainable Management Fund (SMF) administered by MfE, the Sustainable Farming Fund (SFF) administered by the Ministry of Agriculture and Fisheries (MAF), and special funds for promoting the protection of privately owned stands of indigenous forest.

2.1.5.1 Public Good Science & Technology funds

The PGS&T is the largest source of public research funds in NZ. It is administered by the Crown Entity FoRST, who annually invest nearly $400 million into research on behalf of the NZ Government. FoRST has a number of investment focuses, including 11 sustainable development portfolios that broadly include sustainable land-based industries, SRM, environmental protection, and sustainable cities (FoRST, 2002). Approximately $57.42 million has been made available for investment towards these 11 portfolios during 2003.

2.1.5.2 Sustainable Management Fund

The SMF was established in 1995 to provide funding to SRM related projects, including those focusing on the sustainability of land-based industries. Emphasis is given to supporting projects that are community orientated; inductive towards positive environmental change; involve transferable models or procedures; and provide outcomes with a national benefit. To date, approximately 393 individual projects have been supported, representing over $38 million in allocated funding (MfE, 2003).

2.1.5.3 Sustainable Farming Fund

The SFF was established in 2000 as a means to separate support for agriculturally orientated SRM related initiatives. Specifically, it targets 'community driven programmes aimed at improving financial and environmental performance of the land based sectors' (MAF, 2000, p.1), with the intent of building 'rural sustainability' through improved profitability and enhanced social and environmental sustainability (MAF, 2001). In this sense, it is more favourable towards farm sustainability, as opposed other SRM related promotions that tend to focus on the biophysical/ecological/environmental dimension alone.

Maximum funding for any single project is $200,000. To date, 118 projects have been supported, involving the allocation of $13.6 million in funds (MAF, 2003).

2.1.5.4 Funding for biodiversity protection

The protection of natural areas or ecosystems on private or Maori land has become a standalone SRM issue with it's own diverse collection of protection funding programmes. These include the *Nga Whenua Rahui Fund* (protection on Maori land); the *Nature Heritage Fund* (private land); the *Queen Elizabeth II National Trust* (provision for survey, legal and some fencing costs involving protection under a covenant); the *Biodiversity Advisory Service Fund* (support for the provision of biodiversity-management information to land managers); and the *Biodiversity Condition Fund* to support projects involving the protection or enhancement of biodiversity on privately owned land.

2.2. NGOs, COORDINATING STRATEGIES & SLM

It is worth re-emphasising that those with administrative responsibilities under the RMA are concerned primarily with protecting resource integrity and environmental quality (*i.e.* the biophysical/ecological/environmental dimension of sustainability). Many other interests and organisations have a similar concern, but differ widely in how much priority they ascribe to the different dimensions of sustainability. This can be regarded as differences in deciding what to sustain, how to sustain it, and for how long it should be sustained (Chapter 1).

2.2.1 NON GOVERNMENT ORGANISATIONS

Many NGOs have developed their own stance and intent towards SRM or SLM, and may actively work towards bringing their intents into effect. NGOs with an interest in SLM can be divided into three groups:

- *Environmental and recreational organisations* such as Greenpeace, the Royal Forest & Bird Protection Society, the Federated Mountain Clubs, the Ecological Foundation and the Fish and Game Council. These groups have a notable emphasis on the biophysical dimension of sustainability, particularly with the seemingly myopic promotion of environmental quality. Their activities have often persuaded the government to develop new policy or reconsider existing ones (MfE, 1997). Recently, several of these groups implemented a 'dirty dairying' campaign, as a means to influence government and industry policy relating to water quality management on dairy farms (Towle & Hansford, 2002; NZE, 2002).

- *Primary production organisations*, including agricultural industries directly dependent on continued land use (dairy, sheep, beef, arable, horticulture, forestry, deer, and viticulture sectors, along with their organic-production orientated counterparts), supporting industries (*e.g.* the fertiliser industry), and lobby groups (*e.g.* Federated Farmers). Many endorse strong production and economic interpretations of sustainability (organics being the main exception), similar to MAF's definition for sustainable agriculture[2]. Larger organisations may have significant influence over both the actual management of land-based resources, and the development or implementation of government SRM policy.

- *Trust organisations* such as Landcare Trust and the Queen Elizabeth II National Trust. They are included here because they are often perceived as being NGOs, even though they have strong fundamental links with central government. QE II is concerned primarily with the protection of open space features on private land, while Landcare focuses on the promotion of community group approaches to local SRM issues.

[2] Being concerned with SRM as it relates to agriculture, MAF put forward national policy regarding *sustainable agriculture* in 1993. Sustainable agriculture was defined within SLM, with the added requirements of profitability, food safety & quality, and the maintenance of food & fibre production (MAF, 1993). Mention of the biophysical/ecological/environmental dimension was somewhat muted (Blunden *et al.*, 1996), while production and economic dimensions were emphasised.

2.2.2 COORDINATING STRATEGIES

Taken together, the SRM efforts of central government, local government and non-government organisations, whether they be related to research, funding, administration or independent activities, are all coordinated through the national Environment 2010 Strategy (MfE, 2000a). Adopted in 1995, this Strategy details priorities and sub-strategies designed to account for NZ's foremost environmental issues up until the year 2010. Eleven issues are given priority, ranging from 'managing or land resources' through to 'restoring the ozone layer'. Each issue has a corresponding goal, which falls under a six-part Environmental Management Agenda, and the Strategy's Vision (inset).

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The Environment 2010 Strategy's overarching Vision.

Many of the eleven issues identified in the Strategy relate to some aspect of managing land as a resource. As such, priority was given to developing and implementing a standalone sub-strategy, specifically designed to coordinate and promote SLM. The resulting Sustainable Land Management Strategy (SLMS) (MfE, 1996) 'provides a national framework and statement of what the Government intends to do to encourage environmental improvements on commercially-used land' (p.3). Under this Strategy, SLM is to be promoted through support and advice to individual land users, and through the coordination of SLM related services and initiatives (*e.g.* research, extension, local government activities & programmes).

2.2.3 THE RELATION BETWEEN FARM SLM AND SRM

Although the RMA defines sustainable management in relation to natural and physical resources, it does not provide a definition for SLM, despite the importance of land as a national resource. However, with a bit of creativity, the term 'land' can be broadly substituted with 'resource' in the RMA's definition, thereby constructing an environmentally orientated interpretation of SLM. This would align closely with primary interpretations of SLM in Chapter 1, as the ability of management to sustain the biophysical sustainability of land, over-time.

The SLMS also fails to provide an explicit interpretation of SLM, although a rather inadequate definition as 'the management of land resources within their natural limits' is put forth in a preceding discussion document (MfE, 1995, p.3). In lieu of an explicit definition, the SLMS lists a set of seven 'desired outcomes' that hint at the types of biophysical resources that are to be sustained (Figure 2.7). In a sense, these represent national SLM policy that RAs are encouraged to recognise.

1. Maintenance of the potential of NZ soils for a range of uses for present and future generations
2. Adoption of land management skills and the application of appropiate technologies to enable people to provide for their socio-economic wellbeing
3. Adoption of management practices that maintain or enhance water quality regarding contaminants that include harmful microbes, sediment and nutrients
4. The avoidance, mitigation, and remediation of the impacts of land-related hazards, including flooding, subsidence and erosion
5. The maintenance of catchments to provide high quality water resources for downstream users and for users of coastal spaces

Figure 2.7: National policy regarding SLM selected from 'desired outcomes' in the SLMS (MfE, 1996, p.5).

Other desired outcomes in the SLMS relate to the maintenance of cultural, aesthetic, ecological and conservation values. While these may carry equal weighting when the sustainable management of all land in NZ is being considered, they become subsidiary reasons when the emphasis refocuses on farmed land and farm sustainability. In this case, the first and second outcomes often assume dominance (*i.e.* the principal 'why' of SLM within farm sustainability), although it is recognised that farmers are increasingly being encouraged, coerced or forced to recognise less-utilitarian reasons for managing the biophysical dimension of sustainability.

Implicitly, the SLMS uses a selective interpretation of land that only includes soil and water resources. Other more comprehensive definitions exist (Chapter 3), many of which include natural flora, fauna and the ecosystems in-which they inhabit. While the SLMS recognises this as biodiversity, it does not include any desired biodiversity outcomes. Rather, such outcomes are afforded under the SLMS's sister strategy, the Biodiversity Strategy (DoC & MfE, 2000). Those concerning land broadly focus on halting the decline of indigenous habitats and ecosystems, *inter alia*, on both private and public land.

Because land includes soil, water and natural ecosystems[3] as resources, then SLM is interpreted here as being synonymous with the sustainable management of soil, water and natural ecosystems. As a consideration of farm sustainability, this translates to the sustainable management of soil, water and natural ecosystems *on farm land*[4]. In effect, this again represents the management of the biophysical base that farming systems are built upon, as discussed in Chapter 1.

[3] Ecocentrically, nothing can be natural or unnatural because people and their activities are a part of ecosystems to begin with. However, for practical purposes, the term 'natural ecosystem resources' is used here to describe unfarmed flora & fauna and their habitats, particularly as they relate to wetlands, dunelands, tussock land, scrubland, and indigenous forest remnants, which may exist on agriculturally-used land.

[4] This includes on-farm management to avoid, counteract or mitigate off-farm environmental impacts.

REGIONAL AUTHORITY SURVEY

2.3. INTRODUCTION

This section presents results from a nationwide survey aimed at identifying how regional authorities are actually implementing their sustainable land management (SLM) policy. While all New Zealand authorities have defined policy open to examination, such policy does not necessarily translate to how authorities are actually promoting SLM. Internal dysfunction, misinterpretation, lack of communication and lack of resources may all contribute to discrepancies between intended and the actual implementation of policy. Hence, it is important to focus on implementation rather than the policy itself, to gain a more representative indication of how authorities are promoting SLM.

Identifying how authorities are actually promoting SLM also has directly important implications towards farm sustainability. Authorities are required to promote SLM for the common good, which may conflict with why agricultural resources are managed for the good of individuals and the farming community. Under the Resource Management Act (RMA, 1991), authorities have considerable regulatory and coercive powers, and can have a strong determining influence on the what, why and how of resource management within farm sustainability.

Interview survey was used to assess how authorities are promoting SLM. A survey was used in preference to policy analysis to gain a more representative insight into actual methods of implementation, as opposed to intended or planned methods of implementation. Results are presented primarily as tables with a brief discussion. Emphasis is given to broad interpretation because of the sizeable number of NZ regional authorities, and the complex and intertwined nature of policy instruments.

2.4. METHOD

Investigating how SLM is being promoted throughout NZ involved the design of a questionnaire targeting senior representatives from each of NZ's 16 regional authorities, initially intended to be implemented through mail survey. Prior testing of the questionnaire resulted in a major redesign, and the subsequent adoption of an interview approach over mail survey (based around a structured and semi-structured questionnaire). However, failure to rigorously test in an interview setting caused problems and subsequent omission of part of the questionnaire. Participants were nominated through their attendance at the September 2000 Land Managers' Meeting, engaged through email, and interviewed in-person during a national study tour.

2.4.1 QUESTIONNAIRE

A three part questionnaire was designed for the study (Appendix II). The first part involved broad policy instruments, while the second was orientated towards identifying specific SLM programmes used by each regional authority. The third part represents a stand-alone study concerning farm plans reported in Chapter 6. Policy instruments represent tools used by regional authorities to implement their policy, while delivery/extension methods represent the avenue through which policy instruments are delivered.

Part One was divided into two questions as an attempt to distinguish regulation, assistance and education instruments, from those used as extension or delivery instruments. Both questions use the same structure of three sub-questions based on a 1-5 LIKERT scale. Such a scale was used because the original intent was to analyse the responses through statistical procedures. The participant was asked to rank the present degree of instrument use;

how they predict that degree of use is likely to change in the next 5-10 years according to existing council trends; and how the participant would personally like to see the instrument's use change over the next 5-10 years. In doing so, the questionnaire attempted to separate participants' informed and professional judgements from their personal opinions.

Scales were presented diagrammatically beneath each question to aid interpretation. Policy instruments and methods of delivery were listed, and defined on an appended document (Appendix II). Definitions were for the interviewer's reference, and were explained to the participants during the course of each interview. A total of six questions were given, to be answered according to eleven policy instruments and ten extension/delivery methods, giving a grand total of 63 individual potential responses.

Instruments and delivery/extension methods were identified through general literature review (Morriss, 1998; Sapsford, 1998 & 1999; Kneebone *et al.*, 2000; MfE, 2000b), and the targeted review of Regional Policy Statements and regional plans to isolate which types of policy instruments are being used to fulfil policy objectives.

Whereas Part One focused on individual instruments and delivery/extension methods, Part Two was concerned with discrete SLM programmes that group many instruments and delivery/extension methods as a package. Seven questions were presented. The first was used to ask respondents to name and list the SLM programmes their respective authorities use to promote SLM, followed by the other questions asking the respondents to indicate: land use(s) targeted with each programme; targeted environmental issues and their relative priority; farmer constraints that each programme aims to address; types of instruments used in each programme; types of extension/delivery methods used; and a 1-9 ranking of perceived programme effectiveness (ranging from 'no desired outcomes effected' through to 'all desired outcomes effected'. Questions were presented with several coded optional replies, whereby codes were entered into a table according to each stated SLM programme.

The third section of the questionnaire concerning environmental farm plans is explained and discussed in Chapter 6.

2.4.2 CHOICE OF SURVEY METHOD

The original intent was to use a mail survey due to the extensive geographical area covered by regional authorities, and the difficulty and cost of visiting each regional authority office. However, after testing (see below), it was decided to redesign the questionnaire as a basis for an interview survey. Reasons for this include:

1. Approaches currently being used to promote SLM is a complex topic. Application of the study through mail survey would have required considerable supporting information. Such information would be necessary to explain what an instrument is, what the defining features of the listed instruments are, and instructions were considered necessary for the somewhat confusing structure. The volume of required documentation would be considerable, and was likely to be a factor detracting from a positive survey response.

2. A relatively low cost method of interviewing regional authority representatives in person was identified (Section 2.1.4).

3. Interview procedures are recognised as the most effective way of enlisting cooperation towards a positive survey response (Floyd, 1993). The regional authority representatives targeted are busy people, and may have

been comparatively disinterested in participating in a mail survey, relative to accommodating someone who was prepared to make the effort and investment to visit each regional authority in person.

4. Face-to-face interviews can be used to provide additional information through the manner and tone that participants adopt when making a response. Likewise, otherwise hidden or suggested information may be extracted through careful prompting, which cannot be achieved through mail survey.

2.4.2.1 Choice of question types

Types of questions included are classed as 'structured and semi-structured'. Structured questions are similar to 'closed' questions used in mail survey (Chapter 7), but are differentiated by their application through interviewing. In this case, the respondent is asked a question, and is given a number of predefined options to chose an answer from. The advantage of this approach is that questions can be fully explained and clarified during the interview, but the responses are quick to record and easy to collate. As with all closed questions, disadvantages include: a risk that important options may be omitted; questions may be leading; and the introduction of bias if options suggest a common theme (Erdos, 1983).

In contrast, semi-structured questions follow a similar approach, but differ by inviting the respondent to elaborate on a given question if he or she so desires. The advantage is the extraction of a greater depth of information, that may otherwise remain hidden when structured closed questions are used. Disadvantages include the provision of excessive information; disproportionate information if the respondent only explains responses in depth for a select range of questions; distraction and 'getting off the topic' as the respondent follows his or her own train of thought; and additional time required for collating and interpreting responses.

Scaled LIKERT style questions are used extensively in the first part of the interview questionnaire (Appendix II). They are distinguished in having five relative orders of rating (*e.g.* ranging from 'not used' through to 'extensively used'). Five-order LIKERT questions are used because there was no reason in this survey to use greater than five orders, and using less than five does not provide an adequate degree of separation for interpreting meaning from the responses.

Along with strengths and weaknesses of other types of closed questions, those based on the LIKERT scale carry the additional advantage of consistent and uniform responses (for easy collation), but also the additional disadvantage of monotony and repetition that may lead to boredom.

A special type of question system is used in Section 2 of the questionnaire. To facilitate the recording of predefined options according to the SLM programmes (programmes are not defined by the respondent until the interview takes place), coded optional responses are used. The respondent is asked to list SLM programmes, and then assign codes representing options to each programme. The advantage is the use of a 'closed' and structured question approach, which can be tailored to the unforeseeable number and scope of SLM programmes that a regional may provide. The main disadvantage is the time taken to become familiar with the method during the interview.

2.4.3 QUESTIONNAIRE TESTING

The questionnaire was tested on the author's supervisors by review rather than mock application. Testers were asked to provide feedback on question clarity, appropriateness, and achievability. The initial questionnaire was found to be overly complicated and difficult to follow, and was likely to contribute to a poor response rate if mail survey was used. As a result, the questionnaire was redesigned for application through interview survey, and subsequently retested using the same method.

2.4.3.1 Interview duration

The minimum time taken to fill out the questionnaire was 30 minutes for a brief and curt response, with a maximum of one hour predicted for more lengthy responses. Accordingly, participants were informed that the interview should take only 30-60 minutes of their time, depending upon how comprehensively they choose to respond.

The very first interview highlighted this as an embarrassing miscalculation. Part One alone took close to a full hour to complete, indicating that prior testing had been grossly inadequate. This resulted in one participant feeling misled, and the other being imposed-upon to complete the questionnaire at a later date.

In hindsight, this problem should have been addressed by repeatedly testing the questionnaire beforehand, through mock applications, and perhaps with the involvement of local regional authority representatives. Fortunately, the questionnaire was designed in a way that allowed the second part to be omitted from the remaining interviews, without unduly compromising the integrity of the study over-all. The discomfort caused from this lack of initial rigour will ensure the author will never again embark upon a survey without extensive and diverse testing.

2.4.4 INTERVIEW APPROACH AND IMPLEMENTATION

The questionnaire was implemented by interviewing representatives from each of New Zealand's sixteen regional and unitary councils on a one-to-one basis. This was undertaken over a 2-3 month period starting on the 7th November 2000, and ending on the 19th January 2001. Interviews were recorded and subsequently transcribed.

2.4.4.1.1 Participants

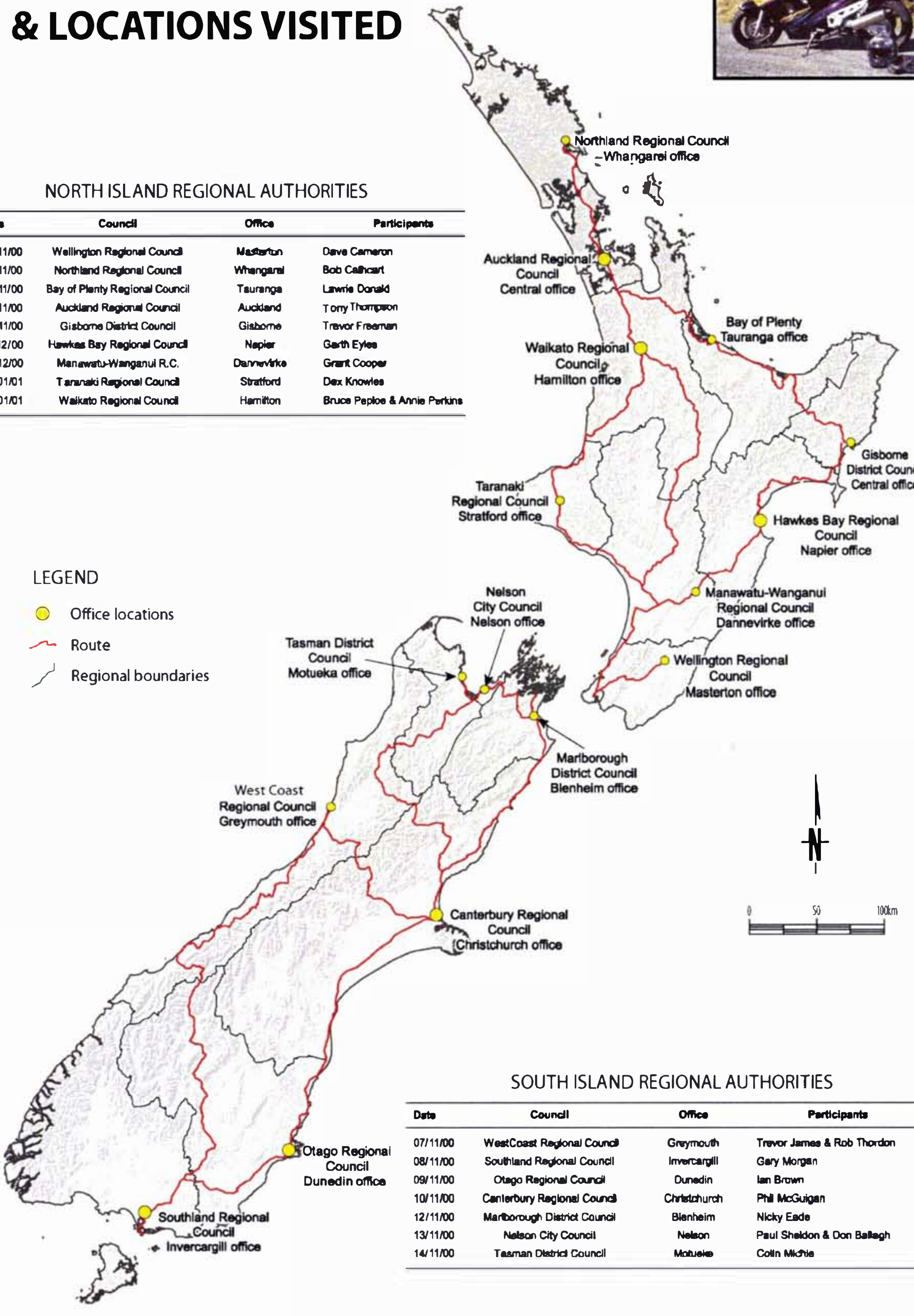
Participants nominated for potential inclusion were identified from their attendance at the September 2000 Land Managers' Meeting. This is a six-monthly meeting between representatives from each regional and unitary council, who have senior management responsibilities toward applying their council's resource management policies concerning agricultural land use. Accordingly, members of this group have an in-depth knowledge and understanding of the instruments and extension methods their respective councils use to promote and effect SLM.

The study was briefly introduced at the September Meeting by Garth Eyles (Senior Land Manager for Hawkes Bay Regional Council), who warned the group to expect a request for participation. Contact details were obtained through council websites. Email was used to distribute a request on the 27th of October 2000. Responses from all sixteen council representatives were eventually positive. Names of participants are included in Figure 2.8.

2.4.4.2 Interview structure

A general interview structure was followed, beginning with a background to the study and an overview of the questionnaire. Specific questions and definitions were sequentially explained in detail as the interview proceeded. Participants were initially asked to adhere to the questionnaire structure by circling their responses on the scales provided. However, some were uncomfortable with having to interpret their responses into the rigidity of this type of questionnaire (*i.e.* according to LIKERT scales), and preferred to explain their council's SLM activities using the questionnaire as a discussion framework only. While this would negate the use of statistical procedures for later analysis (as originally intended), a greater breadth of insight into council SLM activities resulted.

STUDY TOUR ROUTE & LOCATIONS VISITED



NORTH ISLAND REGIONAL AUTHORITIES

Date	Council	Office	Participants
15/11/00	Wellington Regional Council	Masterton	Dave Cameron
23/11/00	Northland Regional Council	Whangarei	Bob Cathcart
24/11/00	Bay of Plenty Regional Council	Tauranga	Lawrie Donald
27/11/00	Auckland Regional Council	Auckland	Tony Thompson
28/11/00	Gisborne District Council	Gisborne	Trevor Freeman
12/12/00	Hawkes Bay Regional Council	Napier	Garth Eyles
13/12/00	Manawatu-Wanganui R.C.	Dannevirke	Grant Cooper
19/01/01	Taranaki Regional Council	Stratford	Dex Knowles
23/01/01	Waikato Regional Council	Hamilton	Bruce Peploe & Annie Perkins

SOUTH ISLAND REGIONAL AUTHORITIES

Date	Council	Office	Participants
07/11/00	WestCoast Regional Council	Greymouth	Trevor James & Rob Thordon
08/11/00	Southland Regional Council	Invercargill	Gary Morgan
09/11/00	Otago Regional Council	Dunedin	Ian Brown
10/11/00	Canterbury Regional Council	Christchurch	Phil McGuigan
12/11/00	Marlborough District Council	Blenheim	Nicky Eade
13/11/00	Nelson City Council	Nelson	Paul Sheldon & Don Ballagh
14/11/00	Tasman District Council	Motueka	Colin Michie

Figure 2.8: Location of council offices and names of participating senior land managers interviewed between 07/11/00 and 19/01/01. Inset: Suzuki GSX 750FG used in the study.

At the end of each interview, the participant was asked to indicate the level of confidentiality they wanted ascribed to the information they had provided. An invitation to review a draft of this chapter was also given. All indicated that they would like to see the draft (some councils have had negative experiences from their involvement with previous university studies, which they attributed to misreported and liberal interpretation of data).

2.4.5 STUDY TOUR

Operational offices of each senior land manager are sporadically distributed across the length and breadth of New Zealand, with distances between each office being considerable (Figure 2.1). The financial cost associated with physically visiting all these offices in person initially made this study infeasible. However, this problem was overcome by undertaking the study via the transport means of a motorcycle.

The annual New Zealand Association of Resource Managers (NZARM) Conference held in November (2000) at Timaru (South Island) provided a starting point for the tour. Many of the study's participants were present at the Conference, allowing general dates and times for interviews to be established. After the Conference, specific dates and times were arranged by phone one or two days ahead, more or less at the participant's convenience. In cases where it wasn't convenient, the sequential pattern of moving from one council to the next closest council was interrupted, although this didn't unduly strain the study's timetable or budget. In this respect, the motorcycle eventuated as being a very versatile means of accounting for the busy schedules of land managers.

The tour took over two months and involved over 13,000km of travel. All of the South Island councils were visited in the first week, with the North Island councils being undertaken at a more relaxed pace.

2.4.6 INFORMATION COLLATION AND ANALYSIS

Each interview was recorded on tape and manually transcribed. In total, this represented over 24hrs of taped dialogue, as each council interview took between 60-100 minutes to complete. In hindsight, the author would not repeat this method because transcription time was considerable.

The initial intent was to analyse responses from Part One of the questionnaire using statistical procedures, and to tabulate and compare SLM programmes for Part Two. Neither has been possible, as Part Two was omitted from the study, and the discussion approach adopted by some participants in Part One negated the use of statistics.

2.4.6.1 Presentation of results

Results are reported by each regional authority as tables and text explanations. Graphical depictions of key regional statistics and SLM policy characteristics are presented as summaries of relevant information used in discussion. Adequately reporting on the results of sixteen authorities has created an extended results section, which is summarised before the discussion. While individual authority results cannot be compared to those of other authorities, trend-lines are erected to explain the emphasis each authority attributed to different aspects of policy instruments and extension/delivery mechanisms.

2.4.7 ETHICAL CONSIDERATIONS

No special ethical considerations were identified for the study. Massey University ethical and instructional requirements for interview surveys have been adhered to, and were explained during the introductory phase of each interview. The study was discussed with members of Massey University's Ethics Committee, and no formal ethics approval was required.

2.4.8 JUSTIFICATION

Several methods based on policy analysis were considered as an alternative to survey. Regional Policy Statements, and particularly regional plans, can be used to provide considerable detail on how each RA intends to promote SLM. However, methods based on policy analysis were discarded because:

- Policy analysis alone cannot be used to identify how RAs are promoting SLM. Discrepancies may exist between intended methods stated in policy, and the actual methods used during implementation. These discrepancies may arise through communication problems between policy-makers and policy-implementers, and policy may be misinterpreted, ignored, or made unviable because of lack of resources. Likewise, policy may be put forward for political and 'politically correct' reasons, but not supported to the degree suggested by RPSs and regional plans. As an example, environmental education may be strongly endorsed in policy, but disproportionably allocated funding for its implementation.

- Many regional plans are not yet operational, which created difficulties in identifying how some RA's are promoting SLM. While a plan with a 'proposed status' may outline a RA's desired method of promoting SLM, this does not necessarily mean the desired method will be legally permissible.

- The combined volume of policy statements, regional plans (and their revisions) and strategies, from all 16 RAs, is substantial. Each has an operative RPS; all have at least one SLM-related plan (*i.e.* not including plans for coasts, air, transport, etc.); and several have between three and five relevant plans. Taken together, this totals at least 58 official policy and planning documents with a direct relation with SLM (not including regional strategies and residual transitional plans). A quality review and analysis would require a considerable investment of time and allocation of dissertation space, both of which would be disproportionate to the thesis overall.

- An immediate alternative was to review general policy only (as stated in RPSs). However, to fit this within a self-preset number of about 30 pages (2 pages per council) required an interpretation of policy at a level too general for meaningful comparison – at this level all councils more-or-less had the same general policy concerning SLM.

- The final alternative attempted was to class RPS stated polices and 'methods of implementation' into general categories of regulation/discouragement, advocacy/promotion, and assistance/education/ incentives, based on qualitative criteria. This functioned well for some councils, but the generality and ambiguity of statements provided by the majority of councils limited the validity of the method.

In contrast, approaching senior land managers was initially considered a more efficient and representative means of identifying how SLM is being promoted regionally (efficiency became questionable due to the time taken to transcribe recorded interviews). Because of managers' hierarchical standing and management responsibilities, they represent the people who are most likely to know how SLM is actually being promoted and effected by their respective authorities.

2.4.9 LIMITATIONS & DIFFICULTIES

1. Individual results for each council have been provided by only one or two council representatives. While senior land managers may perhaps be the best qualified individuals to report on their councils' SLM activities, their views and interpretations do not necessarily represent those officially endorsed by the main council body. An attempt to accommodate possible differences has been made by referencing council policy, and by designing the questionnaire in a way that separates the participant's informed and professional judgement from their personal opinions.

2. The quality of the results was affected by the author's ability to explain the questionnaire, and ask the 'right' follow-up questions. Extended motorcycle travel reduced this ability considerably, particularly during the South Island segment. This has resulted in some councils being reported in more relevant detail than others.

3. Participants varied widely in their openness and willingness to divulge information. Some were overtly frank, to the point where some comments could not be documented because they either scandalise other councils, the farming community, or even the respondent's own councillors. Likewise, some participants were comparably more reserved, often framing their responses in an official and politically correct manner. In the latter case, much was suggested, but little was stated explicitly to a degree suitable for reporting.

4. Some offices had odd acoustic properties that didn't become apparent until the tapes were transcribed. While the recorder was placed close to the interviewee, some responses were not altogether clear.

5. Regional authorities are dynamic in how they implement policy. **Results presented in this chapter are only relevant to the period between late 2000 and early 2001**.

6. This study only broadly investigated how regional authorities were promoting and effecting SLM. Part Two of the questionnaire was designed to elicit the specifics, but was omitted because of time & design constraints.

7. Survey responses cannot be directly compared between councils. The degree of use ascribed to any given instrument is relative to a council's use of other instruments. A valid comparison would require the establishment of a common standard between councils.

8. This is far from being an objective study. Kerlinger (1992) and de Vaus (1995) outline the many shortcomings of studies based on surveys and interviews, most of which centre around the ability and willingness of both the interviewer and interviewee to be objective. Accordingly, any inferences made from this chapter should be tempered against a recognition that the results may not be flawlessly representative of how regional authorities are attempting to promote and effect SLM.

2.5. RESULTS

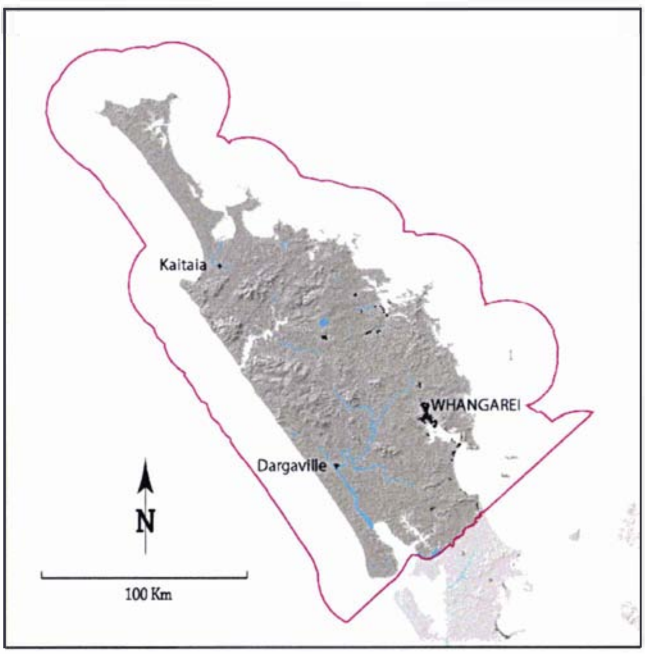
Results for each RA are presented in geographical sequence, beginning with Northland and ending with Southland. Each authority is briefly introduced, including a pictorial summary containing information and statistics derived from RPSs, regional plans, and recent annual reports. This is included to convey a degree of context to each authority's use of policy instruments. Results are presented as tabulated summaries and briefly discussed. It is re-emphasised that **results apply to the 2000-2001 period only**.

2.5.1 NORTHLAND REGIONAL COUNCIL

Northland Regional Council administers a large area of land and coastal waters (Figure 2.9) with a low population density (0.1 people/ha), and a low council revenue ($31.6m below the combined revenue median of all RAs, and $40.4m below the mean). SLM issues include those experienced across all regions (namely water quality & quantity, soil degradation & loss, and issues surrounding biodiversity & indigenous habitats), with weeds and pests being recognised as a priority problem. Indeed, the interviewee (Bob Cathcart) laconically remarked 'we grow the best weeds in the country'.

Four principal methods of policy implementation are explicitly recognised in the Northland RPS: education & advice; regulation or rules; provision of facilities or services; economic incentives or disincentives (Northland RC, 1999). Education is regarded as a key method (Northland RC, 1995). This was reinforced by the interviewee, who when asked to summarise the Council's overall approach to promoting SLM, stated that the preferred and supported approach was '95% education and 5% regulation'. However, it was acknowledged that this applied more towards land and soil management, as opposed to water management that required a greater degree of monitoring and compliance.

NORTHLAND REGIONAL COUNCIL SUMMARY



AREA: *1.27 million ha of land* & 1.77 million ha of coastal waters*

POPULATION: *132,000*

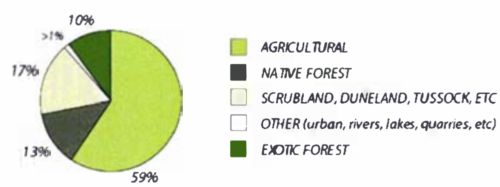
REVENUE: *$14.4 million in 2001/2002*

EXPENDITURE: *$12.6 million in 2001/2002, of which 2.96 million (23%) in 'land operations'*

RPS TARGETED SLM-RELATED ISSUES:
- *Water quality*
- *Soil con. & land mgt.*
- *Water quantity (flows)*
- *Ecosystems & biodiversity*

RELEVANT PLAN STATUS
- *Regional Water & Soil Plan (proposed)*

REGIONAL LAND USE*



** Derived from NZLRI (see Appendix 3)*

Figure 2.9: General summary for Northland Regional Council.

Overall preference for education over regulation was given with a temporal proviso. Northland's main methods relating to the promotion of SLM are stated in their proposed Regional Water & Soil Plan. This Plan is designed to cover a ten year period, during which education represents the preferred overall approach to SLM promotion. However, if after ten years the Council is still faced with significant problems of unsustainable land use that were not addressed through education, then the preference may shift towards a greater use of regulation. This has implications regarding SLM monitoring by councils, and the ability of farmers to be proactive (discussed later).

The Northland interview represents an example of how fatigue impaired the interviewer's ability to pursue detailed responses (particularly in regard to the preferred change in a given instrument's use). However, as presented in Table 2.1, both technical services and education were noted as being major instruments, which was a status unlikely to change within the next 10 years. In contrast, financial incentives/assistance and covenants were 'used', but this use was likely increase in the short-term. Likewise, the minor use of competitions/awards was also likely to increase. A change from minor use of management agreements was not given, while any short-term change in regulation was uncertain due to the provisional status of the Regional Water & Soil Plan.

	Current use	Probable change in use	Preferred change in use
Financial incentives	Used: primarily through a contestable environmental grants fund that provides for riparian mgt, bush protection, erosion control, etc.	Slight increase in use provided increased funding can be secured	Agreed with a slight increase in use, but with a preference for traditional soil conservation methods of fund allocation (cf. existing contestable, lottery-like funding)
Financial disincentives	*Chose not to distinguish economic disincentives associated with regulation*	*Chose not to distinguish economic disincentives associated with regulation*	*Chose not to distinguish economic disincentives associated with regulation*
Technical services	Major use in the area of SLM (but minor relative to all council activities)	Probably no change in the near future	No change
Competitions, awards & prizes	Minor use linked with an environmental component of a business award.	Likely to increase slightly. Described as being 'right on the fringe' of developing this instrument further.	Agreed with a slight increase in use
Financial assistance	*Chose not to distinguish financial incentives from assistance*	*Chose not to distinguish financial incentives from assistance*	*Chose not to distinguish financial incentives from assistance*
Regulation	Minor use (Council policy is 5% regulation, 95% education)	Possible slight increase depending on policy and plan development, and then later on farmers' progress towards SLM	*No preference given*
Tradable rights & duties	Not used	Unlikely to be used (no change)	*No preference given*
Covenants	Used, but typically in association with QEII Trust. In particular, environmental funds for weed control more likely to be allocated for covenanted land	Likely to increase slightly, as the Council seeks to protect more significant natural areas	Agreed with a slight increase in use
Management agreements	Minor use as an agreement between land owners and council regarding the long-term management of plant pests	*Did not indicate if use was likely to change*	*Did not indicate preference for a change in use*
Education to assist	Major use – Council SLM activities function under the philosophy of 5% regulation & 95% education	No change over 5-10yrs, but a possible decrease in use after ten years (with an increase in regulation) if education fails to promote widespread adoption of SLM practices	Supported the current degree of use (no change)
Education for promoting & encouraging	*Chose not to distinguish educational assistance from promotion & encouragement*	*Chose not to distinguish educational assistance from promotion & encouragement*	*Chose not to distinguish educational assistance from promotion & encouragement*

Table 2.1: Northland Regional Council usage of general instruments for promoting SLM.

Subcategories for financial instruments, education, information and community groups were not distinguished. Promotion and provision of information received a status of major use that was unlikely to change (Table 2.2), alongside care-type community groups that would probably increase in use in accordance with community interest. Farm visits and regular publications were used, while DIY kits, focus farms, field days, and discussion groups were all used in a minor way. Of these, only the DIY kits were likely to increase in use in the near future.

	Current use	Probable change in use	Preferred change in use
Promotional material	Major use	No change	No change
Fact sheets & info packages	*Chose not to distinguish promotional material from fact sheets/information packages*	*Chose not to distinguish promotional material from fact sheets/information packages*	*Chose not to distinguish promotional material from fact sheets/information packages*
DIY kits	Minor use; supports VSA	Slight increase in use	*No preference given*
Farm visits (1 to 1 consultation)	Used	*Did not indicate any probable change*	*No preference given*
Focus farms	Minor use; don't have their own focus farms but participate in MRDC Monitor farms	No change	No change
Field days	Minor use; don't organise many of their own field days, but rather integrate with other parties	Likely to increase slightly as they seek to run their own field days	*No preference given*
Farmer discussion groups	Minor use; integrate with Livestock Improvement groups where possible	No change	No change
Landcare groups	*Chose not to distinguish Landcare from other care groups*	*Chose not to distinguish Landcare from other care groups*	*Chose not to distinguish Landcare from other care groups*
Other community groups	Major use; involved with Northland's 30 (approx.) care groups (but few explicitly focus on the care of 'land' *cf.* coast, rivers, etc.)	Possibly a major increase in use; interest in care groups was increasing, & staffing was being reviewed to accommodate this increase	*No preference given*
Regular publications	Used; regular council reports in the local newspaper	Unlikely to increase	*No preference given*

Table 2.2: Northland Regional Council usage of extension/delivery methods for promoting SLM.

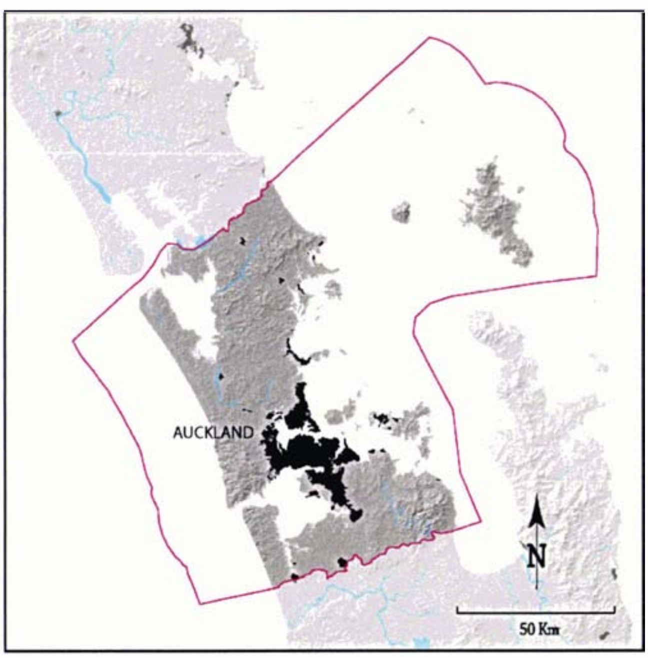
2.5.2 Auckland Regional Council

The Auckland Region has NZ's largest population (1.209 million) contained within an area of 0.55 million hectares (mean density of 2.4 people/ha). The proportion of metropolitan to rural area is high, which coupled with a high rate of population growth, contributes to the Region's principal issue of urban sustainability. Although this may overshadow rural sustainability somewhat, at least five major SLM issues are recognised in the Regional Plan for air, land and water (Figure 2.10). Auckland Regional Council (ARC) receives one of the country's highest regional revenues at $127.6 million, which is $81.6 million above the regional median and $72.9 million above the mean.

The Council have examined their choice of policy instruments in considerable detail, including the production of a standalone Section 32 Report (ARC, 2001b) to accompany the Regional Plan (ARC, 2001a). Recognised instruments include those listed in MfE (2000b) (see Section 2.1.4), along with advocacy/liaison, and Codes of Practice (*i.e.* recommended resource management practices). The RPS (ARC, 1999) only lightly touches on categories of policy instruments. In briefly reviewing policy and plans, no single instrument or combination of instruments, could be identified as the preferred or dominant approach to SRM promotion.

This was reflected in the interviewee's (Tony Thompson) response when pressed about the Council's overall approach. It was emphasised that several internal groups have responsibilities relating to SLM, with each taking a different approach in their method of implementation. Hence, while it was stated that the land management group favoured education, overall this may be distorted by other groups with a strong reliance on regulation (*e.g.* those with responsibilities for issuing consents regarding earthworks and discharges).

AUCKLAND REGIONAL COUNCIL SUMMARY



AREA: *0.55 million ha of land & 1,613km of coast line*

POPULATION: *1.209million*

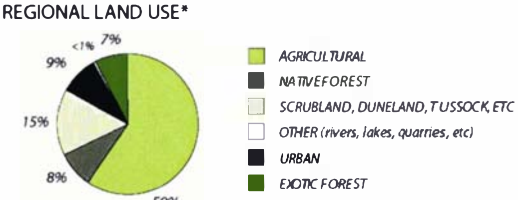
REVENUE: *$127.6 million in 2001/2002*

EXPENDITURE: *$126.8 million (2002), of which $26.3 million (20.7%) in 'environmental quality' & 'sustaining our heritage'*

SLM-RELATED ISSUES (from Regional Plan):
- *Soil conservation & soil health*
- *Water quantity & quality in rivers & streams*
- *Water quality in lakes*
- *Wetlands & Groundwater*
- *Natural heritage*

RELEVANT PLAN STATUS
- *Regional Plan: air, land & water (proposed)*
- *Farm Dairy Discharges Plan (operational)*
- *Regional Sediment Control Plan (proposed?)*

REGIONAL LAND USE*



** Derived from NZLRI (see Appendix 3)*

Figure 2.10: General summary for Auckland Regional Council.

Reasons for the land management group's principal use of education is related to preference and politics. On the preference side, education is seen to be a more suitable approach for dealing with long-term rural issues that relate to private land (*cf.* regulation). Politically, the regional dominance of urban sustainability issues overshadows rural sustainability issues, such that the use of positive financial instruments in the rural sector is not supported to any great degree. Lack of support for a grants scheme was surprising, because ARC has one of the highest revenues, but administers New Zealand's second smallest regional area. With a disfavour for regulation and a political barrier for financial instruments, education and related advocacy becomes the land management group's default overall approach.

Low Council support for financial instruments is reflected in the degree of instrument use (Table 2.3). The use of such instruments may increase slightly in the future, but only for the specific area of riparian and wetlands management. The interviewee would like to see a considerably greater use of financial incentives, and a slight increase in grants for care-type groups. Instruments ascribed a status of major use included services and education (education subcategories were not distinguished). Provision of services may increase if a farm planning programme is developed, while education is unlikely to change despite a preference for a slightly greater use.

	Current use	Probable change in use	Preferred change in use
Financial incentives	Minor use	Possibly a slight increase in use; the provision of subsidies for riparian & wetland mgt had been informally discussed	Would prefer to see a considerably greater use of this instrument
Financial disincentives	Not used directly	No change	No change
Technical services	Major use	Perhaps a slight increase depending on the development of a farm planning service	No change
Competitions, awards & prizes	Used; a general environmental award scheme that spans both urban & rural	No change	Would prefer a slight increase in use
Financial assistance	Used but in a context of subsidising group schemes rather than individual farmers	No change	Would prefer a slight increase in funding for care-type groups
Regulation	Minor use	Slight increase	No change
Tradable rights & duties	Used	No change	No change
Covenants	Used; typically through, or in association with, QEII Trust	Possibly a slight decrease in use	Strongly preferred a considerable increase in the use of covenants
Management agreements	Very minor use; farmers sign a non-binding 'memorandum of understanding' as part of a Trees for Survival programme	Slight increase in use if a farm planning service was adopted	Supported a slight increase in use
Education to assist	Major use	No change	Would like to see a slight increase
Education for promoting & encouraging	*Chose not to distinguish educational assistance from promotion & encouragement*	*Chose not to distinguish educational assistance from promotion & encouragement*	*Chose not to distinguish educational assistance from promotion & encouragement*

Table 2.3: Auckland Regional Council usage of general instruments for promoting SLM.

Financial disincentives are not directly used (*i.e.* they are not distinguished from economic considerations of regulation), nor are they likely to be used in the future. Competitions/awards and covenants are used in an indirect manner. It would be unlikely that their use would increase significantly in the future, although an increase would be preferred (particularly for covenants). Management agreements are used in a limited capacity, and may increase slightly in use if a farm planning programme was adopted. Likewise, regulation receives minor use, but may increase slightly in the future (reasons for this were not discussed). Similarly, the current and future use of tradable rights were not discussed.

High reliance on promotional material and provision of information (Table 2.4) reflects the overall emphasis on education. The current level of information provision is unlikely to change, although promotion may increase slightly. Regular publications were used indirectly for rural communities, and may increase slightly if a newsletter similar to Gisborne's Conservation Quorum could be developed. Council focus farms are not supported but they may be used in the future. Field days are used, and may increase in use. Farm visits may be undertaken following a specific enquiry, but were limited by low staff numbers for further use. The greatest likely and preferred changes in extension/delivery methods related to DIY kits and group-based approaches.

	Current use	Probable change in use	Preferred change in use
Promotional material	Major use	Probably a slight increase	Supported a slight increase
Fact sheets & info packages	Extensively used; reflective of a strong emphasis on education	No change	No change
DIY kits	Used	Considerably more use	Supported considerably more use
Farm visits (1 to 1 consultation)	Used; if an enquiry is made, then a land management representative may undertake a farm visit	No change	No change
Focus farms	Not used	May be used in the future in the context of riparian management	Would support the use of this instrument
Field days	Used	Slight increase	Supported a slight increase
Farmer discussion groups	Minor use through Livestock Improvement discussion groups	Considerably more use	Supported considerably more use
Landcare groups	Major use	Considerably more use	Supported considerably more use
Other community groups	Minor use; includes other 'care' groups, the Water Quality Monitoring Programme, & rural land users liaison forum	Slight increase	Supported a slight increase
Regular publications	Minor use for the rural community (two generic region-wide publications are used)	Slight increase for rural communities	Supported a slight increase, perhaps along the lines of Gisborne DCs Conservation Quorum

Table 2.4: Auckland Regional Council usage of extension/delivery methods for promoting SLM.

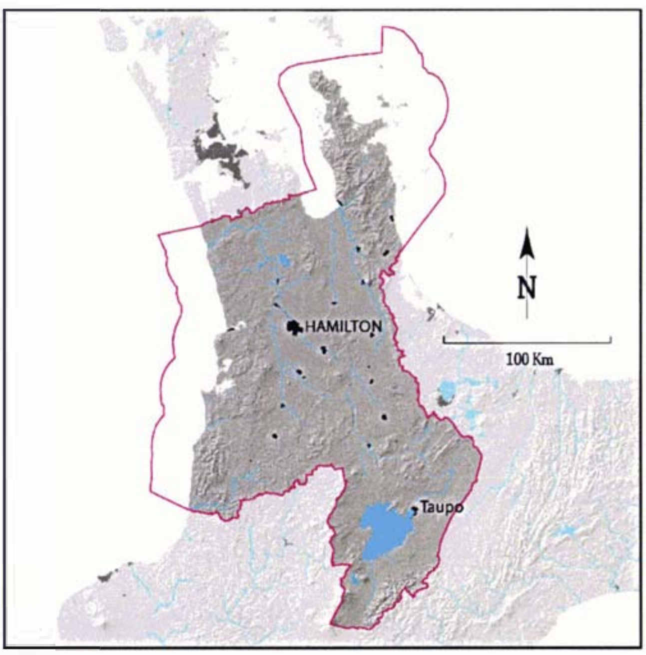
2.5.3 Waikato Regional Council

Waikato has a large regional area (2.45 million hectares) but a low mean population density (0.15 people/ha). An annual revenue of $42.3 million is below both the national median (-$3.7m) and mean (-$12.5m). Dairy farming is one of Waikato's more distinguishing land uses, with over half the regional businesses in the early 1990s being dairy farms (EW, 2002a). Many SLM issues described in the RPS strongly relate to dairy farming (particularly in regard to water quality and riparian management), although hill country erosion is recognised as a significant issue for 43% of the Region (EW, 2001). Biodiversity has also recently received particular attention.

Two Council staff were interviewed at the Hamilton office of the Waikato RC (Bruce Peploe & Annie Perkins). Unfortunately considerable difficulties were experienced after this interview had taken place, particularly with the clarity of the recorded dialogue. Not all of the tape could be transcribed. For this reason, some of the following discussion has been supplemented from strategic plans (EW, 1995 & 2001), the RPS (EW, 2002a), and the Regional Plan (EW, 2002b).

During the interview, it was indicated that the Council uses a broad mix of instruments to promote SLM, characterised by a strong emphasis on education and community partnerships. This aligns closely with official policy – a major shift in implementation policy was indicated in 1995, whereby "environmental education will be incorporated into all of Environment Waikato's activities" (EW, 1995, p.20). Environmental education is now organised as one of the Council's nine primary works programmes, and recognised ahead of other key instruments: 'we use environmental education, incentives and information as well as regulation, and actively encourage people to participate in environmental issues' (EW, 2001, p.10).

WAIKATO REGIONAL COUNCIL SUMMARY



AREA: *2.45 million ha of land* & 0.95 million ha of coastal waters*

POPULATION: *368,000 (2001 estimate)*

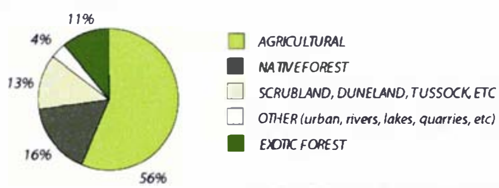
REVENUE: *$42.3 million (2002)*

EXPENDITURE: *$50.5 million (2002); $5.4 million on 'land & soil'; $8.5 million on 'inland waters'*

SLM-RELATED ISSUES (from RPS):
- *Agricultural waste*
- *Maintaining biodiversity*
- *Wetlands & public access*
- *Destabilisation of river/lake beds*
- *Water quality, flows, & efficient use*
- *Soil health, contamination, erosion & drainage*

RELEVANT PLAN STATUS
- *Regional Plan (proposed)*

REGIONAL LAND USE*



** Derived from NZLRI (see Appendix 3)*

Figure 2.11: General summary for Waikato Regional Council.

As individual instruments, education was recognised as receiving extensive use, while the use of incentives (defined by the Council to include awards and financial grants) was either high or increasing (Table 2.5). The annual Farm Environment Awards programme was instigated in 1993, and formed into a multi-sponsored Trust in 1995 (as part of a strategic shift towards greater use of incentives). The use of financial incentives/assistance has recently been accelerated, particularly with grants being made available for biodiversity protection, and the establishment of a Riparian Protection Fund ($10 million committed over 10 years) to 'support landowners who want to protect and enhance their creeks, streams and river bank margins' (EW, 2001, p.6).

Regulation is simply 'used'. According to the 1995 Strategic Plan, consents and compliance-monitoring were expected to increase up until a peak in 2000 (EW, 2001). Interview responses suggest this may have happened, as the future use of regulation is likely to decrease. The Council recognises that 'regulation on its own will not achieve long-term change' (*ibid.*, p.10). One interviewee stated that regulation 'has a place… but more as a last resort', which is similar to ideas of regulation as backstop to protect the environmental bottom line.

	Current use	**Probable change in use**	**Preferred change in use**
Financial incentives	Used	Increased use, 'the Council is certainly heading in the direction of more incentives' particularly in relation to riparian & biodiversity management	Supported a slight increase, although in a judicious manner: 'I don't think we should be going overboard with financial grants'
Financial disincentives	Not used directly	*Response could not be distinguished*	Did not support – was more in favour of using positive methods of inducing change
Technical services	Used; 'we provide a lot of information, advice & support'	Likely to increase with the development of catchment schemes	Supported an increased use
Competitions, awards & prizes	Major use through the Farm Environment Award Trust	No change	Supported no change
Financial assistance	*Chose not to distinguish financial assistance from incentives*	*Chose not to distinguish financial assistance from incentives*	*Chose not to distinguish financial assistance from incentives*
Regulation	Used	Possible slight decrease in use	Supported a slight decrease: 'it has a place… but more of a last resort'
Tradable rights & duties	Not used	No change	Supported no change, although it was acknowledged 'they may have merits in certain situations'
Covenants	Used; integrate with QEII Trust	Probably an increase; EW was in the process of developing their own covenant, and "there's a lot of political pressure to use them'	Supported a slight increase
Management agreements	Minor use; 'we use them from time to time'	Likely to increase slightly with the development of catchment schemes	No preference given, although it was stated that covenants are preferred over management agreements
Education to assist	Extensively used; "we're very strong on education", particularly as the provision of information, advice and training	Likely to increase in tandem with the development of catchment schemes	Supported any increase
Education for promoting & encouraging	*Chose not to distinguish educational assistance from promotion & encouragement*	*Chose not to distinguish educational assistance from promotion & encouragement*	*Chose not to distinguish educational assistance from promotion & encouragement*

Table 2.5: Waikato Regional Council usage of general instruments for promoting SLM.

Provision of services was afforded a status of 'used', particularly as it relates to groups and other forms of collective extension. This is reflected in the major and extensive use of field days and Landcare groups, relative to the low-key use of farm visits and associated one-to-one consultation. This preference was related to the large number of small holdings (namely dairy farms) distributed across the Waikato's extensive regional area; Landcare groups and field days represent a more efficient means of engaging a large number of farmers. However, one-to-one services remain a proverbial tool in the Council's toolbox, and may even increase in use as a component of new catchment schemes (*i.e.* as a means to engage farmers in a catchment disinterested in groups, seminars and field days).

Landcare groups are particularly well established in the Waikato. The Council's website (www.ew.govt.nz) reports a total of 28 groups operating across the Region, involving approximately 350 participants. Support provided to groups can include technical advice and information; facilitation; networking with other groups; organisation of training seminars and field days; and financial support (at the time of the interview, this could be up to 35% of the costs for an approved project).

	Current use	Probable change in use	Preferred change in use
Promotional material	Used	No change	Supported no change
Fact sheets & info packages	Major use	Possibly a slight increase	Supported a slight increase
DIY kits	Minor use for water quality monitoring	Increased use; were considering soil monitoring kits and DIY farm planning models	Did not indicate a preference, but stated that Waikato would not necessarily automatically assume kits developed by outside agencies
Farm visits (1 to 1 consultation)	Used	No change	*No preference given*
Focus farms	Not used	*Response could not be distinguished*	*Response could not be distinguished*
Field days	Major use	*Response could not be distinguished*	*Response could not be distinguished*
Farmer discussion groups	Minor use; integrate with industry groups	Possibly a slight increase; "its something we're looking to do more of"	No preference given
Landcare groups	Extensively used; Landcare is 'very active in the Region'	Increased use; Landcare as a movement was continuing to grow	Supported any increase
Other community groups	Minor use as sheep & beef liaison groups	*No change indicated*	*No preference given*
Regular publications	Used, including Landcare newsletters; *envirocare* (region-wide environmental newsletter); catchment scheme newsletters	Slight decrease in use; less involvement with Landcare newsletters	*No preference given*

Table 2.6: Waikato Regional Council usage of extension/delivery methods for promoting SLM.

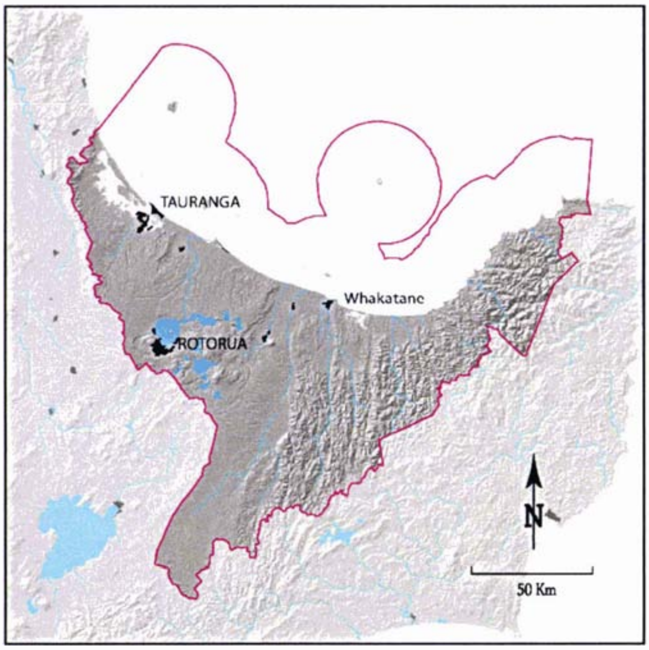
2.5.4 Bay of Plenty Regional Council

Bay of Plenty Regional Council have the distinction of the highest regional revenue at $129.2 million, which is well above the national mean (+$83.2 million) and mean (+$74.4 million). They administer a moderately large land area (NZ's 8th largest regional area) with a low population density (0.18 people/ha). SLM issues are diverse (Figure 2.12), and as discussed during the interview, are considered more manageable than similar issues faced by some other regional authorities. The Council also has a notably high degree of integration and collaboration with territorial authorities regarding SRM and SLM responsibilities.

General methods of promoting SRM are only lightly introduced in the Council's RPS (EBOP, 1999), but those relating to land are covered in detail within the Regional Land Management Plan (EBOP, 2002). The Plan acknowledges 'a general desire... to move away from... confrontational methods', in favour of education, advocacy, guidelines, services and economic instruments (*ibid.*, p.57). However, in seeking 'to be proactive and firm in establishing boundaries to acceptable land management' rules were also considered necessary as the 'environmental bottom line' (*ibid.*). Taken together, the Council is pursuing a balance of promotion, restriction and monitoring, as the best means to achieve it's desired SLM outcomes. Indeed, this is explicitly captured as policy: 'to use an efficient and effective balance of methods to achieve the purpose of this plan' (EBOP, 2002, Policy 8.1.3a, p.60).

A balanced use of key instruments was also stated as the overall approach used by the Council during the interview. This was given in a context of the monitoring and compliance group (who focus on restrictions) balancing the operations and rural services group (who focus on the promotion dimension). The interviewee (Laurie Donald) was part of the latter group.

BAY OF PLENTY REGIONAL COUNCIL SUMMARY



AREA: *1.22 million ha of land* & 0.9 million ha of coastal waters*

POPULATION: *224,365*

REVENUE: *$129.18 million in (2002)*

EXPENDITURE: *$98.57 million (2002); $3.6m biosecurity; $826,000 land management; $1.2m envr enhancement*

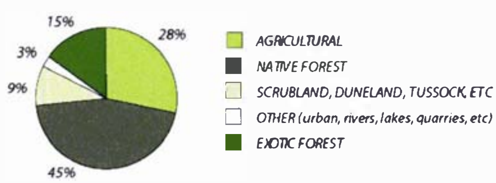
SLM-RELATED ISSUES (from RPS):

- *Riparian & wetland areas*
- *Pests (& weeds)*
- *Soil conservation*
- *Water quality & quantity*
- *Adverse effects of land use & land productivity (soil sustainability)*
- *Natural character & indigenous ecosystems*

RELEVANT PLAN STATUS

- *Onsite Effluent Treatment Regional Plan (operative)*
- *BoP Regional Land Management Plan (proposed)*
- *RP for Tararawera River Catchment (proposed)*
- *Regional River Gravel Management Plan (proposed)*
- *Regional Water & Land Plan (draft)*

REGIONAL LAND USE*



** Derived from NZLRI (see Appendix 3)*

Figure 2.12: General summary for Bay of Plenty Regional Council.

A balanced approach is also reflected in the degree of instrument use (Table 2.7), although there was a suggestion that financial incentives/assistance receive particular emphasis, while education was perhaps not being used in a way that distinguished it from advocacy. Education in a training and learning sense was the only instrument that the interviewee would prefer to see a considerably greater use of relative to other instruments. Likewise, financial incentives/assistance were the only instruments to be afforded a 'major use' status, which included a substantial works grant scheme associated with land improvement agreements and environmental programmes (farm plans). It also included a contestable Environmental Enhancement Fund targeting community projects. Relative to many other RAs, the high investment in financial incentives/assistance appears to be distinguishing feature of the Council's approach to promoting SLM (but only relative to other councils; within the BoP it is 'balanced' against the use of other instruments).

The interviewee was not comfortable making a distinction between covenants and management agreements. Land Improvement Agreements are used to protect the investment of public monies, but they were also validly regarded as a form of covenant. A distinct preference for the former was indicated, on the basis that an agreement is more flexible for negotiating an agreeable compromise between conservation, protection and use. Use of agreements was likely to increase, although the legality of extending Land Improvement Agreements to cover the protection of on-farm natural areas was uncertain at the time.

	Current use	**Probable change in use**	**Preferred change in use**
Financial incentives	Major use; up to 50% subsidy/grant rate available for 'environmental weed' control, pest control, and retirement fencing	No change	Perhaps a slight increase
Financial disincentives	Not used directly	Unlikely to change	Wouldn't like to see a change
Technical services	Used, particularly as they relate to the preparation of environmental plans	Unlikely to change	Content with the current degree of use
Competitions, awards & prizes	Used, particularly to promote the Council's own image	*Did not indicate a probable change in use*	*No preference given*
Financial assistance	*Did not choose to distinguish between financial incentives and assistance*	*Did not choose to distinguish between financial incentives and assistance*	*Did not choose to distinguish between financial incentives and assistance*
Regulation	Used	Probably no change	Preferred no change
Tradable rights & duties	Not used (although EBOP has strong links with territorially constituent District Councils who do)	Unlikely to change	Supported the concept of tradable rights but did not indicate if a greater use was preferred
Covenants	Minor use as Conservation Covenants and QEII open space covenants.	Unlikely to change	Preferred no change; considered these types of covenant too inflexible; preferred management agreements
Management agreements	Used; 'Land Improvement Agreements' are used in grant schemes	Perhaps a slight increase with a recent policy swing towards greater protection of biodiversity/natural habitat on farms	No preference was given, although they were actively looking at alternative forms of mgt agreements that could better accommodate the biodiversity dimension of land improvement
Education to assist	Used, but perhaps more in an advocacy and promotional sense. Minor use in a training & learning sense.	Slight increase	Would like to see a considerably greater use of education for learning & training
Education for promoting & encouraging	*Chose not to distinguish educational assistance from promotion & encouragement*	*Chose not to distinguish educational assistance from promotion & encouragement*	*Chose not to distinguish educational assistance from promotion & encouragement*

Table 2.7: Bay of Plenty Regional Council usage of general instruments for promoting SLM.

In contrast to the Council's interpretation and overall use of education, the operations and rural services group did not use promotional material for SLM, but instead made major use of fact sheets or information packages (Table 2.8). DIY kits, field days and focus farms were not used or supported to any notable degree. Industry-led farmer discussion groups were used if an invitation was forthcoming. At the time, no Landcare groups were in operation in BoP, although there were several Coastcare and Dunecare groups. However, as Landcare groups were likely to increase in the Region, the Council would be willing to offer their services where and when appropriate. The interviewee was agreeable towards supporting Landcare groups.

Extensive use was made of one-to-one farm visits. Indeed, it was stated this represents a significant component of the operations and rural services group, particularly in relation to the preparation of environmental programmes (farm plans). Including direct links with associated instruments, the interviewee considered this to be the most effective approach for promoting SLM.

	Current use	**Probable change in use**	**Preferred change in use**
Promotional material	Not used	*Did not indicate a probable change in use*	*No preference given*
Fact sheets & info packages	Major use	No change	Content with the current degree of use
DIY kits	Not used	Perhaps a slight increase if VSA is adopted, and interest in care groups continues to grow	Was not particularly interested in DIY kits, on the basis that few individuals have the time or inclination to use them
Farm visits (1 to 1 consultation)	Extensive use; represents a significant component of all 'operations and rural services'	No change	Content with the current degree of use; actually states 'its really the only useful way' [for effecting change]
Focus farms	Not used. However, biodiversity mgt. is monitored on 6 farms (*i.e.* post-protection rate of regeneration, weed invasion, bush health, etc.)	No change	*No preference given*
Field days	Not used directly; may 'tie into' field days organised by other parties.	No change (will continue to integrate with other field days if possible)	No preference given, although it was considered that the time required to organise a Council field day was not adequately offset by the benefit
Farmer discussion groups	Used; will integrate with industry groups if the opportunity arises	No change	No change
Landcare groups	Not used (see below)	Landcare groups are likely to increase in the BOP. EBOP will offer their services to new groups	No preference given, although the idea of Landcare groups was supported (on the basis that it takes the Council 'out of the loop'
Other community groups	Used, but only in relation to coast-care type groups	Probably an increase	No preference given
Regular publications	Minor use	No change	No preference given, but the interviewee was against adding to the unlooked for material 'that turns up in peoples letter boxes

Table 2.8: Bay of Plenty Regional Council usage of extension/delivery methods for promoting SLM.

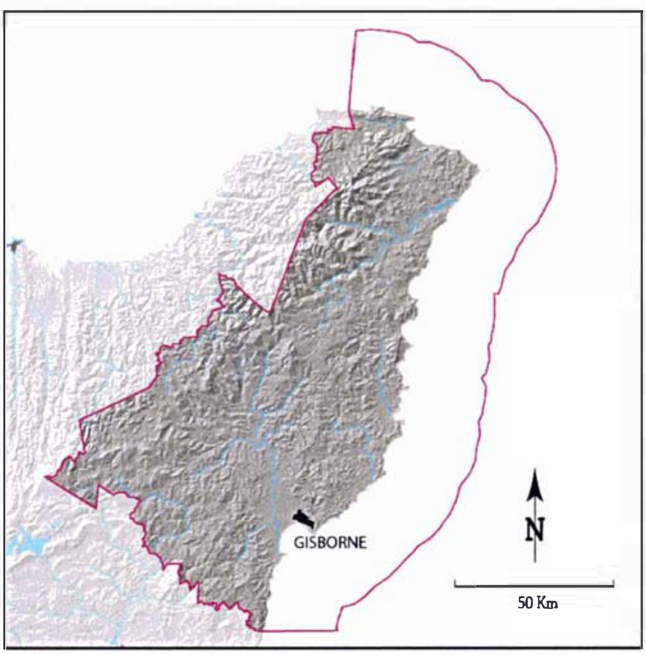
2.5.5 Gisborne District Council

Gisborne District Council is distinguished by having some of the most difficult to manage SLM issues in New Zealand, particularly in relation to inland erosion occurring on rugged and remote hill country farms. Pastoralism on many of these farms has been highlighted as an unsustainable land use (in a long-term, whole-farm context), and considerable efforts have been directed at encouraging or ensuring land use change to forestry or conservation retirement (including through New Zealand's only Government funded soil conservation subsidy scheme – the East Coast Forestry Project).

The GDC administers a sizeable area of land (Figure 2.13) with a very low population density (0.05 people/ha). A seemingly high revenue of $53.9 million ($7.9m above the national median but slightly below the mean) is distorted by the Council's unitary function: this income represents the total amount of money available for both regional and district responsibilities. Removing Government forestry subsidies ($10.2m) and expenditure on roading, urban services and reserves ($27.8m), leaves only $16m available for the Council's other responsibilities (including other district responsibilities).

GDC's use of instruments to promote SLM tend to focus on soil conservation. This is reflected in the combined District Plan and Regional Plan (GDC, 1997), which details policy for erosion but is rather light on detail for other SLM issues (as acknowledged in the RPS – GDC, 2002, p.48). However, a broad representation of instruments is recognised, including: information & advice; provision of works & services; economic & other incentives; advocacy; regulation; and voluntary agreements (GDC, 2002). In briefly reviewing both the RPS and combined Plan, no overbearing preference for a single type of policy instrument was stated.

GISBORNE DISTRICT COUNCIL SUMMARY



AREA: *0.83 million ha of land* & 0.53 million ha of coastal waters*

POPULATION: *43,971*

REVENUE: *$53.87 million (2002)*

EXPENDITURE: *$56.5 million (2002)*

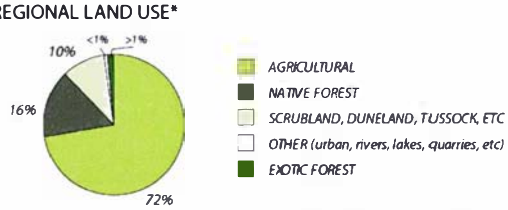
SLM-RELATED ISSUES (from RPS):

- *Soil erosion*
- *Pests & weeds*
- *Loss of versatile soils*
- *Natural values*
- *Public access to natural features*
- *Unsatisfactory water quality*
- *Point & non-point pollution*
- *Water demand & inefficient use*

RELEVANT PLAN STATUS

- *Regional Plan for Discharges to Land & Water... (proposed)*
- *Combined Regional Land & District Plan (proposed)*

REGIONAL LAND USE*



** Derived from NZLRI (see Appendix 3)*

Figure 2.13: General summary for Gisborne District Council.

The GDC's overall approach was made clear during the interview. Relative to many other councils, the GDC relies heavily on regulation to promote and ensure SLM. This was somewhat of a surprise (*i.e.* that any RA would even admit to a strong use of regulation), but understandable when the magnitude and difficulty of redressing the District's issues is considered against the Council's funding position. In short, regulation dominates because it is considered cheap, although it was stated that this is tempered by 'mixing it with advocacy and education'.

An emphasis on regulation was also apparent in the degree of instrument use (Table 2.9). This relates mainly to rules regarding land use activities, and restrictions on actual land uses (*i.e.* some land-uses require a consent). The Council is seeking to increase their use of this instrument slightly, which was strongly supported by the interviewee.

A preference for considerably more use of financial incentives/assistance and management agreements was also given. However, at present these two instruments are not used (cannot afford a substantial grants scheme), but this may increase slightly in the future. A slight increase from the minor use of competitions and awards was preferred, provided care was taken to include a diversity of farmers (having 'the same group of farmers' applying year after year, could distort the effectiveness of this instrument).

	Current use	**Probable change in use**	**Preferred change in use**
Financial incentives	Not used directly by the Council. However, a degree of incentive/ assistance is afforded through the Gov funded Eastcoast Forestry Project	Perhaps a slight increase	Would like to see considerably more use of this instrument
Financial disincentives	Not used directly	No change	Supported no change
Technical services	Major use	No change	Supported no change
Competitions, awards & prizes	Minor use	No change	Would like to see a slight increase
Financial assistance	*Chose not to distinguish between financial incentives and assistance*	*Chose not to distinguish between financial incentives and assistance*	*Chose not to distinguish between financial incentives and assistance*
Regulation	Major use	Perhaps a slight increase	Would like to see considerably more use
Tradable rights & duties	Not used	No change	Supported no change
Covenants	Minor use; support & integrate with other covenanting schemes	No change	Supported no change
Management agreements	Not used	Slight increase in use; regarded as a more flexible means of accommodating cultural ethics for Maori owned land	Would like to see considerably more use
Education to assist	Major use	No change	Supported no change
Education for promoting & encouraging	Major use	No change	Supported no change

Table 2.9: Gisborne District Council usage of general instruments for promoting SLM.

The Council also makes major use of services and education. Both were considered to be strongly interrelated, as the act of providing a service facilitates the process of education. This also has strong links to the extensive use of one-to-one farm visits (Table 2.10), which was considered integral to a successful SLM programme: 'you get far better response by dealing with people as individuals… as individual farms'. This was discussed in a context of community group initiatives, as a recognition that a group approach may be resource efficient, but it then needs to extend down to individuals in order to be effective.

The only other instrument to standout was the use of a regular publication for SLM promotion. This is the *Conservation Quorum*, which is regularly distributed to the District's farmers. This contains information on topical issues, Council activities, and District facts. Perhaps more importantly, it also seeks to remind farmers of upcoming seasonal SLM management requirements (*e.g.* when space planting should begin so farmers can pre-order poplar poles). Many other RAs were very complementary towards this newsletter.

	Current use	**Probable change in use**	**Preferred change in use**
Promotional material	Minor use	No change	Supported no change
Fact sheets & info packages	Minor use	No change	Supported no change
DIY kits	Minor use	Slight increase in use	Would support a slight increase in use
Farm visits (1 to 1 consultation)	Extensively used	No change	Supported no change
Focus farms	Minor use	No change	Supported no change
Field days	Used	No change	Supported no change
Farmer discussion groups	Not used	No change	No change
Landcare groups	Not used	No change; previous Landcare initiatives in the District had been unsuccessful	No preference given
Other community groups	Minor use	No change	Supported no change
Regular publications	Major use; GDC regularly publish Conservation Quorum focused on keeping farmers informed about SLM	No change	Supported no change

Table 2.10: Gisborne District Council usage of extension/delivery methods for promoting SLM.

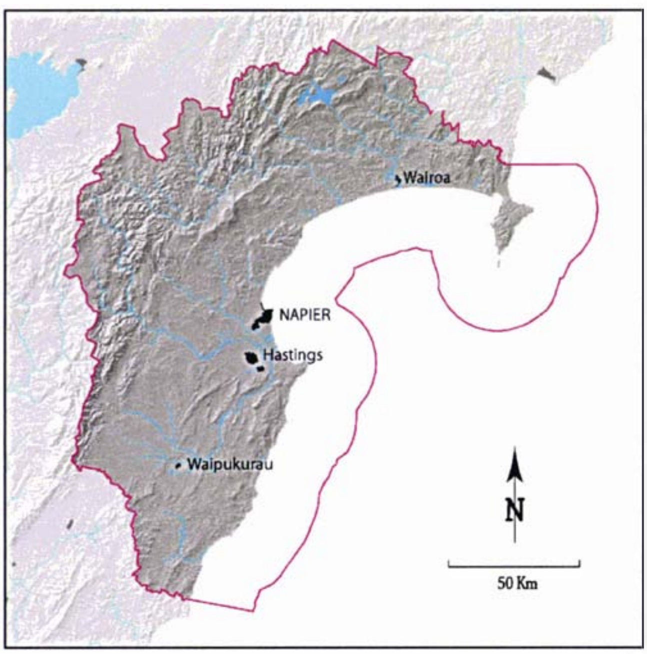
2.5.6 Hawkes Bay Regional Council

Hawkes Bay Regional Council administers New Zealand's tenth largest regional land area (1.42m ha), with a low mean population density (0.1 people/ha), and a modest revenue ($46m in 2001) that aligns closely with the national median, but is $8.7m below the mean. Noted SLM-related issues are common to those experienced by other regions (Figure 2.14), distinguished perhaps by explicitly recognising the problem of farmers inconsistently matching land use to land capability (HBRC, 2001a).

HBRC include their RPS within the proposed Regional Resource Management Plan (HBRC, 2001b). Three relevant methods of implementing policy are put forward as an alternative to regulation: environmental education and coordination; economic instruments; and the provision of works and services. No single instrument was identified as characterising the Council's overall approach, although it was stated that the 'HBRC is placing increasing emphasis on environmental education and coordination' as means to fulfil it's SRM responsibilities (*ibid.*, p.99).

The interviewee (Garth Eyles) indicated that the overall method used when dealing with farmers involved firstly encouraging them to change, and then helping them change through grants and services. This was also stated as a combination of financial grants, one-to-one consultation, and the provision of services. Hence, overall, the Council can be considered to use a balanced approach skewed towards assistance and direct liaison.

HAWKES BAY REGIONAL COUNCIL SUMMARY



AREA: *1.42 million ha of land* & 0.71 million ha of coastal waters*

POPULATION: *144,292*

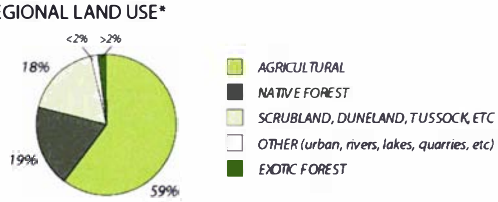
REVENUE: *$46.01 million (2001)*

EXPENDITURE: *$36.58 million (2001); 20% on pests & weeds; 33.2% on environmental management*

SLM-RELATED ISSUES (from SOE Report):
- *Ground water quantity & quality*
- *Surface water flows, quality & ecology*
- *Matching land use with capability*
- *Indigenous vegetation & wetlands*
- *Agricultural waste*
- *Soil loss & degradation*
- *Land use nuisance*
- *Pests & weeds*

RELEVANT PLAN STATUS
- *Regional Waste & Hazardous Substances Plan (operative)*
- *Regional Water Resources Plan (operational)*
- *Regional Resource Management Plan (proposed)*

REGIONAL LAND USE*



** Derived from NZLRI (see Appendix 3)*

Figure 2.14: General summary for Hawkes Bay Regional Council.

The interviewee was not initially comfortable with indicating the degree of use for specific instruments: '[they are] just tools… you've just got to use whatever tool is appropriate for the environment you're in'. As such, most instruments listed in Table 2.11 were simply stated as being 'used'.

Instruments that were emphasised during the interview include financial grants, services, regulation and management agreements. The HBRC has a substantial fund ($500,000) attached to a Regional Land Care Scheme, from which grants can be provided for riparian and soil conservation management. The provision of grants was strongly supported by the interviewee, primarily as a means for the community to contribute to regionally beneficial works on private land. Similarly, the provision of services was also strongly supported, not only as means to assist, but also as a facilitating mechanism for advocacy and education.

Regulation was stated as being a tool that receives minor use, but necessary as an environmental bottom line for curbing blatantly unsustainable land use or practice. Minimising the use of regulation has been a philosophy of the HBRC from the outset of policy development. However, this use may increase slightly in the future in response to more intensive land use(s), and it was recognised that central Government and the community may demand greater use of regulation in the future.

	Current use	**Probable change in use**	**Preferred change in use**
Financial incentives	Used, particularly through regional land care schemes. It was emphasised the HBRC provides 'grants' as opposed to 'subsidies'	Perhaps a slight increase if policy relating to biodiversity protection is backed by additional funding	Would like to see a slight increase, as grants 'emphasis the community approach' through public funding of works on private land for public good
Financial disincentives	Not used directly	Probably no change	Preferred no change
Technical services	Used	Perhaps a slight increase if one more staff member was employed	Strong advocate for services: 'I believe you achieve things by knocking on doors and talking to people'
Competitions, awards & prizes	Minor use through a generic environmental award	Perhaps a slight increase	Favoured awards for industry, but admitted they were not having a significant impact at the individual farm level
Financial assistance	*Did not choose to distinguish between financial incentives and assistance*	*Did not choose to distinguish between financial incentives and assistance*	*Did not choose to distinguish between financial incentives and assistance*
Regulation	Minor use	Perhaps a slight increase in the short-term, into targeted areas (*e.g.* dairy farming). Long-term would depend on political pressure.	Supported the minimal use of regulation: 'it needs to be very bottom line… has to be a backstop regulation'
Tradable rights & duties	Not used	Perhaps a slight increase in the area of water rights and allocation	Did not support any increase
Covenants	Used; support and integrate with QEII and DoC covenants	Slight increase for biodiversity protection	Supported a slight increase; was agreeable because covenanting undertaken by other agencies represents a reduced cost to Council
Management agreements	Used in relation to forestry land use and Landcare groups	Slight increase in use	Supported a slight increase, but acknowledged they only work effectively with some people
Education to assist	Used, but no degree of use was stated	Perhaps a slight increase	No preference given – education is regarded as just another tool to be used where and when appropriate
Education for promoting & encouraging	*Chose not to distinguish educational assistance from promotion & encouragement*	*Chose not to distinguish educational assistance from promotion & encouragement*	*Chose not to distinguish educational assistance from promotion & encouragement*

Table 2.11: Hawkes Bay Regional Council usage of general instruments for promoting SLM.

Management agreements are used to obligate Landcare groups and forestry interests. Land Improvement Agreements are not used. Overall, the use of management agreements may increase slightly in the future, although it was acknowledged that they are only effective in some situations with certain people.

The interviewee was more willing to indicate the degree of use for extension and delivery methods (Table 2.12). In particular, the provision of information and one-to-one consultation with farmers were noted as being extensively used, perhaps as a reflection of the interviewee's strong personal preference for these instruments. Promotional material and farmer-based discussion groups receive minor use. An interest in becoming more involved with dairy discussion groups was also expressed.

Focus farms are 'used', primarily through a Northern Hawkes Bay demonstration farm. While this has been successful, a preference was given for a shifting farm-to-farm focus as opposed to the long term examination of issues particular to one farm. Field days are also 'used', but were not strongly supported because they do not necessarily result in tangible outcomes. Funding and services are provided to a number of land- and other care-groups, and pest control groups (coordinated groups of farmers funded to control possum populations at an agreed level).

	Current use	**Probable change in use**	**Preferred change in use**
Promotional material	Minor use	No change	*No preference given*
Fact sheets & info packages	Extensively used; have actively been translating LMO's expert knowledge into information for use by farmers	No change, although different information subjects will be developed as appropriate	Supports the current use of this instrument
DIY kits	Used (HBRC was the first to offer DIY farm planning kits)	Slight increase	*No preference given*
Farm visits (1 to 1 consultation)	Extensively used: 'I would like to visit every farmer in the Bay that we feel we need to visit'	No change	Strongly supported the current degree of use
Focus farms	Used: have a demonstration farm in Northern HB	*Did not indicate a probable change in use*	Would like to see an increase of use
Field days	Used	Perhaps a slight decrease – LMOs are no longer required to organise a previously stipulated 2 field days/yr	Preferred a degree of use that paralleled or justified their use (*i.e.* only when needed)
Farmer discussion groups	Minor use; will work into existing industry groups if possible	Slight increase of use, depending on the willingness of groups to invite LMOs along	Preferred an increase in use, particularly with dairy discussion groups. Seen as an effective means of contacting people
Landcare groups	Used – approximately 8 groups established at the time	No foreseeable change	Unwilling to explicitly state a preference; 'they're a tool... they have their place'
Other community groups	Used – several Coastcare groups and a number of pest control groups	Probably no change	Supported no change in the immediate short term
Regular publications	Used. *Groundwork* is a publication targeted at farmers	No change	Would like to see a stronger emphasis on SLM *cf.* Council publicity in *Groundwork*

Table 2.12: Hawkes Bay Regional Council usage of extension/delivery methods for promoting SLM.

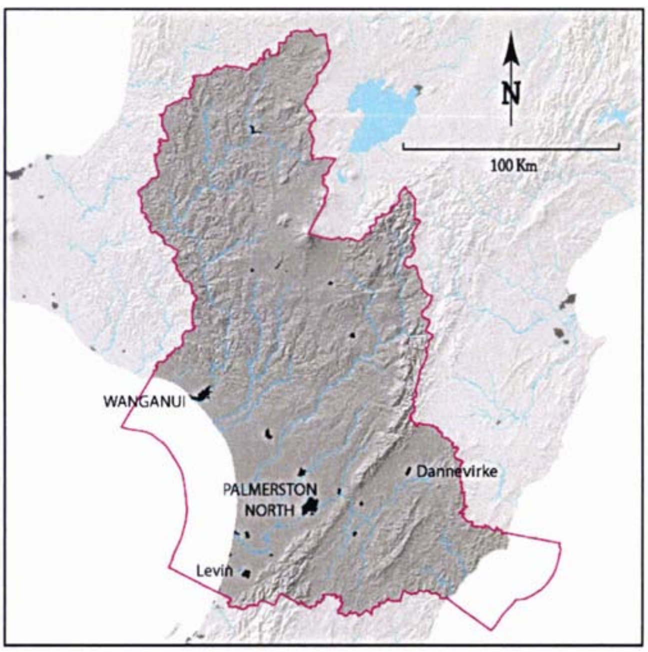
2.5.7 MANAWATU-WANGANUI REGIONAL COUNCIL

Next to Nelson, the Manawatu-Wanganui Region is distinguished as having the smallest area of coastal waters, and the smallest land to sea ratio overall (0.1ha of sea for every 1ha of land). Total land area is 2.22 million hectares, dominated by hill and mountain land (69.6%) but with significant areas of plains, terraces, downlands and sand country (horizons.mw, 1999). Mean population density is similar to Hawkes Bay at 0.1 people/ha, but revenue is considerably lower at \$27.2 million (\$18.8m below median and \$27.6 below the mean). Despite wording, SLM-related issues are essentially the same as those experienced by other regions, but compounded by having an extensive diversity of agriculturally-used landscapes.

Five broad methods of implementing policy are recognised (horizons.mw, 1998 & 2003): provision of information, education & advice; advocacy; incentives; regulation; and the provision of goods & services. Officially, the MWRC favours the provision of information; has a limited ability to provide services; does not consider financial incentives as a practicable means of implementing policy; and makes limited use of other economic instruments (*e.g.* financial disincentives). No explicit standpoint on regulation was stated.

The Council's overall approach stated by the person interviewed (Grant Cooper) was one-to-one advice, backed up by assistance if necessary. It was felt that the Council is not strongly pursuing regulatory approaches, but has a greater preference for advocacy, advice, and education. This was unlikely to change in the near future, although it was acknowledged the specific mechanisms will continue to evolve: "we'll try and get smarter at doing things and use different tools, rather than just the same type of thing for everybody… we'll try and focus on different areas'.

MANAWATU-WANGANUI REGIONAL COUNCIL SUMMARY

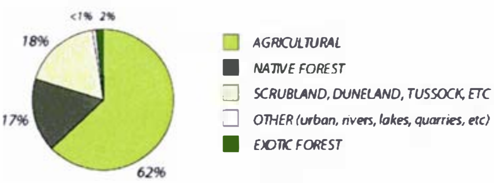


AREA: *2.22 million ha of land* & 0.33 million ha of coastal waters*
POPULATION: 226,617
REVENUE: \$27.19 *million*
EXPENDITURE: *\$26.9 million (2002); \$2.6 million in Land Resource Mgt*

SLM-RELATED ISSUES (from RPS):
- *Understanding of, & attitudes toward, SLM*
- *Loss of productive capability of land (incl. vulnerable soils)*
- *Adverse effects of land use, contaminants, urban growth, & pests/weeds*
- *Decline of natural features, habitats & landscapes*
- *Adverse effects on lakes, rivers & wetlands; surface & groundwater quality & quantity*

RELEVANT PLAN STATUS
- *RP for the Beds of Rivers & Lakes & Ass. Activities (operational)*
- *Oroua Catchment Water Allocation & River Flows RP (operational)*
- *Land & Water Regional Plan (proposed)*

REGIONAL LAND USE*



** Derived from NZLRI (see Appendix 3)*

Figure 2.15: General summary for Manawatu-Wanganui Regional Council.

A preference for assistance is clearly apparent in the degree of instrument use (Table 2.13). This is in the dual context of financial grants and technical services, both of which were afforded a status of major use. While use of grants may increase slightly, the interviewee would prefer the existing grant ratios to remain unchanged (*i.e.* they currently represent an appropriate balance between providing too-much or too-little financial incentive/assistance). Likewise, the use of technical services was unlikely to change, as the current degree is thought to appropriately reflect demand.

Education is used, with a stated preference for future use to be targeted at educating the public, as the Council's existing level of one-to-one interaction facilitates an acceptable degree of farmer education. A biennial environmental award with a farming category is used, but was subject to the problems experienced by other councils (particularly with the same group of farmers applying each time). Regulation receives minor use, mainly to protect the 'environmental bottom line'. However, it was acknowledged that it is used more in water management than land/soil management. Tradable rights are not used, although they have been discussed as an option for managing the Region's increasingly contentious allocation of water resources. This was not supported by the interviewee, as it was felt that market-driven water allocation fails to address unsustainable levels of water consumption.

	Current use	**Probable change in use**	**Preferred change in use**
Financial incentives	Major use; will provide financial grants for soil conservation, riparian works and pest control (fund of $300,000 for 2000)	Slight increase	Preferred no change; considered the existing grant rates to be balanced
Financial disincentives	Not used directly	*No probable change indicated*	*No preference given*
Technical services	Major use	Probably no change	Supported no change; current use of services reflects current demand
Competitions, awards & prizes	Used; environmental award with categories. Offered once every two years	Probably no change	Supported no change, but was conscious of the same farmers applying year after year
Financial assistance	*Did not choose to distinguish between financial incentives and assistance*	*Did not choose to distinguish between financial incentives and assistance*	*Did not choose to distinguish between financial incentives and assistance*
Regulation	Minor use from a soil land perspective, but used more for discharges & water quality	No significant change foreseen	Preferred no change, provided that existing regulation is sufficient as a 'backstop' to blatant resource mismanagement
Tradable rights & duties	Not used	Perhaps a slight increase; dependent on policy regarding water rights and allocation	Did not support any increase; disagreed with a market driven method of allocating water
Covenants	Minor use; support & integrate with QEII covenants	Probably no change	Supported no change
Management agreements	Not used; however, a non-binding agreement is made when grants are provided	Probably no change	Supported no change
Education to assist	Used	Slight increase in use	Would support a slight increase, but orientated more towards educating the public, as farmer education is more often (& more effectively) facilitated through one-to-one contact
Education for promoting & encouraging	*Chose not to distinguish educational assistance from promotion & encouragement*	*Chose not to distinguish educational assistance from promotion & encouragement*	*Chose not to distinguish educational assistance from promotion & encouragement*

Table 2.13: Manawatu-Wanganui Regional Council usage of general instruments for promoting SLM.

As with most other councils, covenants were used through other agencies (namely the QEII Trust). Management agreements were not used, although a farmer is required to sign a non-binding (in a legal sense) agreement when grant monies are exchanged. The interviewee did not favour binding agreements because of the associated time and cost associated with their development and processing, but acknowledged their value as a form of insurance when large grants are involved.

High overall use of one-to-one assistance is also reflected in farm visits, information provision and DIY kits (Table 2.14), which contrasts against the minor use of group extension methods (focus farms, field days, discussion groups, and community groups). Field days were noted as having limited success in the eastern Manawatu/Wanganui, and a greater preference was expressed for integrating more with discussion groups.

	Current use	Probable change in use	Preferred change in use
Promotional material	Minor use	No change, although content & quality will change in the future	Supported no change. In an indifferent way, 'they have their place'
Fact sheets & info packages	Used, particularly in conjunction with farm plans (as appendices)	Perhaps a slight increase as SLM issues become more specific (*e.g.* pugging on hill country *cf.* generic pugging)	Supports an increase, provided they remain appropriately matched with actual issues
DIY kits	Used	Increase in use	Supported increased use
Farm visits (1 to 1 consultation)	Extensively used to promote SLM	May decrease slightly if Council policy orientates more toward group approaches (*e.g.* SUBS)	Agreed with the current degree of use
Focus farms	Minor use; occasionally involved in MRDC monitor farms	No change	Supported no change
Field days	Minor use	Probably no change	Suggested a preference for less use in the Dannevirke area overall, but supported SUBS type field days
Farmer discussion groups	Minor use	Possibly a slight increase	Would support a slight increase
Landcare groups	Minor use – Landcare groups are supported if required	No change	Preferred no change
Other community groups	Minor use – pest control & weed control groups	Possibly a slight increase if the Council seeks a coordinated approach to group pest control	No preference given
Regular publications	*Was not indicated*	*Was not indicated*	*Was not given*

Table 2.14: Manawatu-Wanganui Regional Council usage of extension/delivery methods for promoting SLM.

2.5.8 TARANAKI REGIONAL COUNCIL

Taranaki is a relatively small region, with a land area of 0.7 million hectares, and a mean population density of 0.14 people/ha. Revenue is modest at $36.1 million, which is $10m below the national median and $18.7m below the mean. Like Waikato, Taranaki is often regarded as a dairying region, at least on the extensive ring-plain surrounding Mt. Egmont. However, the Region also includes a substantial area of hill country given to more extensive land uses of sheep, beef and deer farming (also includes large areas of native forest). SLM issues concerning dairy farming tend to skew towards water quality, while those pertaining to hill country focus on erosion. The TRC has two SLM-related regional plans; one for soil and another for freshwater (Figure 2.16).

As with other councils, it is difficult to distinguish a dominating approach to SLM promotion from policy and planning documents alone (unless explicitly stated). General methods of implementation recognised in the TRC RPS include information & advice; regulation; works & services; economic instruments; advocacy; and voluntary agreements (TRC, 1994). No preference for a leading method is given. However, the Regional Freshwater Plan (TRC, 2001a) suggests regulation is the dominant approach for water management (the plan involves 87 rules), while the Regional Soil Plan (TRC, 2001b) contains only one rule, and states a preferred 'partnership with land users' for promoting sustainable soil management (p. i). This partnership will involve the Council committing 'considerable resources' to non-regulatory methods including information/advice, promoting SLM practices, and 'property planning' services (*ibid.*).

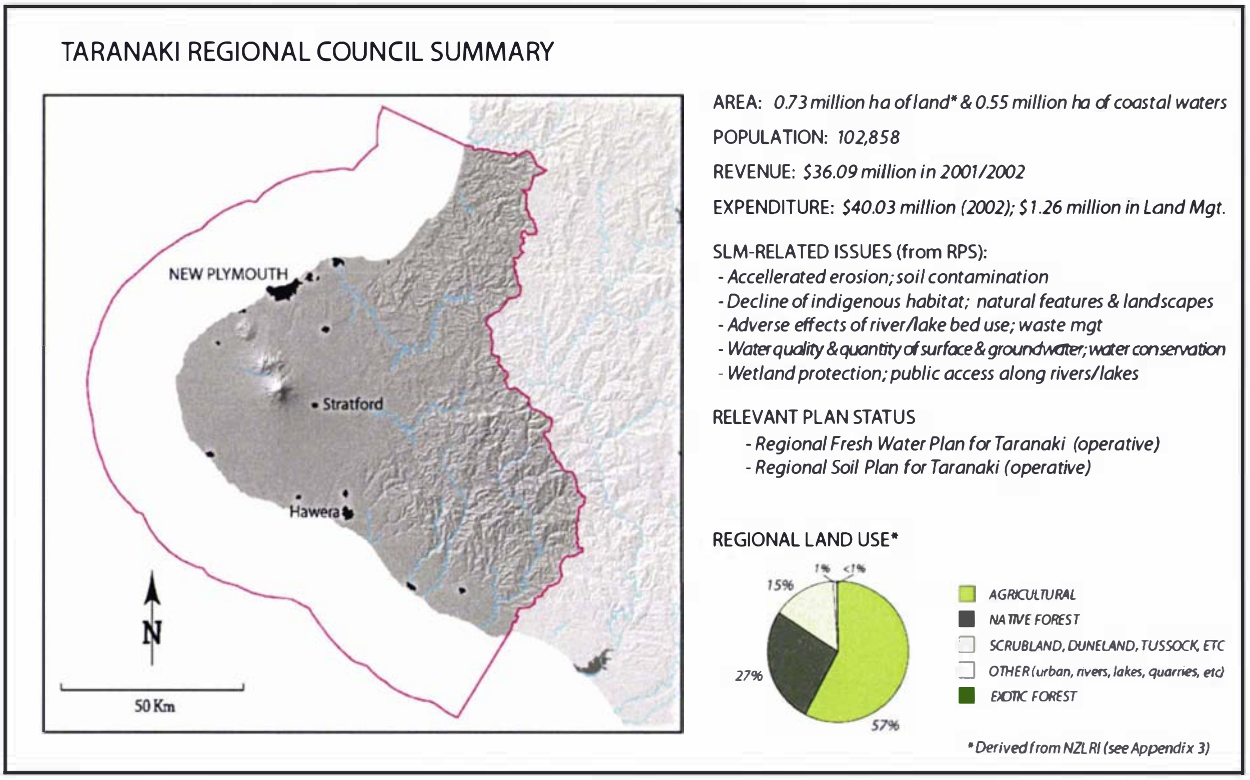


Figure 2.16: General summary for Taranaki Regional Council.

This overall approach was reiterated during the interview with Dex Knowles, who phrased it as 'the provision of advice, information and assistance through property planning services'. Approximately $1.5 million per year is invested in this approach. When asked why this is the dominant approach, it was stated that the Council prefers 'to work in partnership' with land users, particularly as this relates to site-specific management of land. There was a strong recognition that SLM and related issues are particular to individual farms (*i.e.* SLM at the application level), with each farm therefore requiring its own customised set of SLM solutions or options. Extensive use of various property plans (farm plans) allows TRC to achieve this.

Unlike other councils with a farm plan service, TRC has no direct grants scheme to provide financial incentive or assistance to farmers (Table 2.15). No reason for this was given, other than a suggestion that a meaningful grants scheme would simply 'cost too much'. However, it was stated that a minor degree of subsidy is indirectly afforded through nursery plants for works, whereby bulk purchasing allows farmers to obtain plants from the Council at a rate substantially less than commercial prices (approximately 50% less expensive).

Regulation was stated as receiving minimal use, although a comparatively greater use for water management was acknowledged. The single rule contained within the Regional Soil Plan (the rule targets vegetation disturbance on slopes >28^0 and >5ha in area) was considered to convey a unique regulatory status to the TRC. That is, the TRC makes the least use of regulation to promote or effect SLM (relative to other councils), at least as it relates to the sustainable management of soil resources. However, some other regional councils distinguished TRC in being 'hard but fair', and particularly free in the use of abatement notices to control undesirable activities.

	Current use	Probable change in use	Preferred change in use
Financial incentives	Not used	Probably no change	Preferred no change: 'I don't see a need for it'
Financial disincentives	Not used	No change	Preferred no change
Technical services	Extensively used	No change	Supported no change
Competitions, awards & prizes	Used as an annual environmental award described as 'low key'	Possibly a slight decrease in use	Suggested a preference for considerably less use (*i.e.* would like to see them phased out)
Financial assistance	*Chose not to distinguish between financial incentives and assistance*	*Chose not to distinguish between financial incentives and assistance*	*Chose not to distinguish between financial incentives and assistance*
Regulation	Minor use in general, but acknowledged the degree of water management regulation afforded through the regional freshwater plan	Unlikely to change	Supported no change
Tradable rights & duties	Not used	Unlikely to change	Supported no change
Covenants	Used; integrate with QEII & covenants provided by other agencies	Unlikely to change	*No preference given*
Management agreements	Used; includes a legally binding Memorandum of Encumbrance, or a non-binding 'contract of agreement'	Unlikely to change, although a large increase would be expected if the Council began to provide grants	*No preference given*
Education to assist	Major use: "we're hot on education instruments" as they relate to direct liaison with individuals	Unlikely to change	Supported no change; content with the existing level
Education for promoting & encouraging	Used; qualified this as education orientated towards field-days & other mass extension exercises	Slight increase in use	Preferred no change

Table 2.15: Taranaki Regional Council usage of general instruments for promoting SLM.

Management agreements are used by the TRC, including a 'contract of agreement' between two parties (which is non-binding in a legal sense), and a Memorandum of Encumbrance (MoE) to replace Land Improvement Agreements (which the Council no longer considers legally valid for agreements relating to biodiversity and riparian management). Like a covenant, a MoE allows an agreement to be registered against the land title, thereby making it legally binding.

The Council's overall approach is reinforced by a high use of services, education to assist, one-to-one consultation, and information (Table 2.16). All four are interlinked, and their degree of use was unlikely to change in the near future (which is also a status preferred by the interviewee). Education was distinguished as one-to-one education afforded through direct contact with farmers (education to assist), as opposed to education targeting groups and large audiences (education & promotion). Taranaki was the only council in the survey to make this distinction.

Education was linked to a major use of both promotional and factual information. The council has approximately 40 fact sheets available for SLM alone; a similar number for pest management; and around 300 in total (*i.e.* relating to all Council activities). One-to-one contact was also considered important, with up to 8 direct contacts (including 4 farm visits) associated with a comprehensive farm plan on an annual basis.

The use of farmer discussion groups was also notable. This includes integration with industry groups, and the independent use of hill-country groups. Three areas of hill country are recognised, with each being assigned two LMOs. Officers organise and facilitate group visits on a farm-by-farm basis, which may involve an invited guest speaker. Topics relate mainly to SLM, and are tailored to individual farms. This initiative is unique to TRC.

	Current use	**Probable change in use**	**Preferred change in use**
Promotional material	Major use	No change	Supported no change
Fact sheets & info packages	Major use	No change	Supported no change
DIY kits	Not used	No change	Supported no change; not keen on DIY farm plan kits
Farm visits (1 to 1 consultation)	Extensively used	Probably no change	No preference given, but the interviewee is a strong advocate for direct liaison with farmers
Focus farms	Minor use – typically prepare a farm plan for MRDC monitor farms	Probably no change	Preferred a slight increase in use towards SLM orientated demonstration farms with a core group of farmers
Field days	Used in conjunction with other agencies	*No indication given*	No preference given, although the general idea of collaborative field days was supported
Farmer discussion groups	Strong use; organise and facilitated their own hill country discussion groups	Perhaps a slight increase – dependent upon interest & support from farmers	Supported increased use where possible
Landcare groups	Not used (but several coast-care groups exist)	Unlikely to change	No preference explicitly stated, but concern over the effectiveness of such groups was expressed
Other community groups	*Did not chose to distinguish discussion from 'other' community groups*	*Did not chose to distinguish discussion from 'other' community groups*	*Did not chose to distinguish discussion from 'other' community groups*
Regular publications	Used	Probably no change	'I think they're a bloody good idea'

Table 2.16: Taranaki Regional Council usage of extension/delivery methods for promoting SLM.

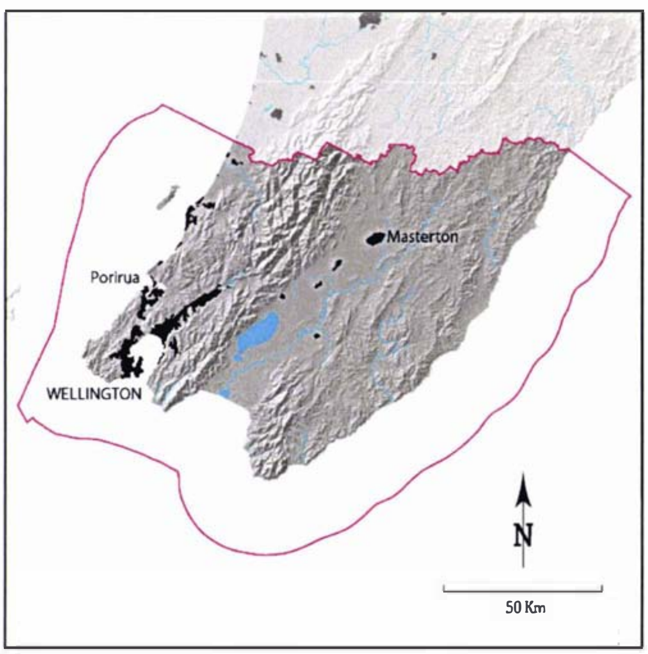
2.5.9 Wellington Regional Council

The Wellington Region is relatively small at 0.8 million hectares of land, but has a moderately high population density (0.5 people/ha) attributable to large urban centres (approx 80% of the population is urban based). Revenue is also high ($1.22m), which is $76.2m above the national median and $67.5m above the mean. SLM issues are similar to those experienced by other councils, although erosion is a particular concern in the eastern hill country.

Wellington Regional Council has a unique administration arrangement as it relates to promoting SLM. The central office is located in Wellington on the western side of the Tararua Ranges, while the greater area of farmed land is located in the east (according to the NZLRI, 14% of the Region's agriculturally used land is located west of the Ranges, and 86% is located in the east). Hence, much of the responsibility (and perhaps a degree of autonomy) for promoting SLM is passed on to the Masterton office, leaving the central office free to concentrate on urban sustainability.

No single method of promoting SLM was identified from the RPS (Wellington RC, 1995), Freshwater Plan (Wellington RC, 1999), or Soil Plan (Wellington RC, 2000). As with other councils, the use of regulation for water management is likely to be high (51 rules in the Freshwater Plan), but low for soil/land management (only 4 rules in the Soil Plan). This is supported in the Background Report to the Soil Plan (Wellington RC, 1997), which recognises that regulation is 'not the best way' of changing unsustainable management of soil resources (p.7). Instead, the Council 'recognises that the most effective method of promoting SLM… in most instances, is by getting alongside land managers and owners and working with them' (*ibid.*). In this sense, the Council officially supports the provision of works and services, information (and education), and advocacy as key alternatives to regulation. Financial incentives are not considered to be 'a useful means… to achieve the purpose of the Act [the RMA]', although incentives for soil conservation are supported under the latent Soil Conservation & Rivers Control Act, 1941 (*ibid.*, p.5).

WELLINGTON REGIONAL COUNCIL SUMMARY



AREA: *0.81 million ha of land* & 0.74 million ha of coastal waters*

POPULATION: *423,765*

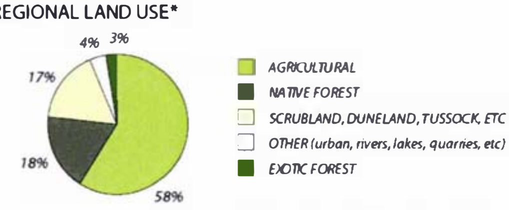
REVENUE: *$122.2 million (2002)*

EXPENDITURE: *$115.5 million (2002); $8.607 million into Land Management*

SLM-RELATED ISSUES (from RPS):
- *Water quality, habitat, river beds, access to, use allocation & efficiency*
- *Soil erosion, contamination, quality, drainage of, loss of versatile soils*
- *Ecosystem decline (diversity, area, quality), pests & weeds*
- *Landscape & heritage*

RELEVANT PLAN STATUS
- *Regional Plan for Discharges to Land (operational)*
- *Regional Soil Plan (operational)*
- *Regional Freshwater Plan (operational)*

REGIONAL LAND USE*



** Derived from NZLRI (see Appendix 3)*

Figure 2.17: General summary for Wellington Regional Council.

The interviewee (Dave Cameron) described the Council's overall approach to the promotion of SLM as a combination of technical assistance and financial assistance/incentives. This was unlikely to change in the near future, although education may be afforded a 'stronger focus'. Regulation 'will always stay in the back pocket… and won't be used as extensively' as the other key instruments.

This was also reflected in the degree of instrument use (Table 2.17), whereby finances, services, and one-to-one education were noted as instruments receiving high use. All three were strongly linked with farm planning, such as the provision of a 35% grants rate for conservation plans, and a 45% rate for sustainability plans (types of plans are discussed in Chapter 6). The Council is unlikely to change this rate, although the interviewee would like to see a return to previous rates of 40% and 50% respectively.

Wellington RC was one of the few councils to officially retain farm planning through the 1980s & 1990s. As a result, they have a longstanding rapport with individual farmers, and considerable experience and expertise in promoting SLM within the Region (at one stage, the staff had over 100 years of combined soil conservation experience). Rephrased, the Council has retained and improved traditional methods of SLM promotion, which orientate strongly towards liasing and working with farmers, on a farm-by-farm basis.

	Current use	**Probable change in use**	**Preferred change in use**
Financial incentives	Extensively used for soil conservation, and linked with farm plans	No change	Would prefer an increase in use
Financial disincentives	Not used directly	No change	Supported no change
Technical services	Major use, particularly as it relates to the preparation and follow-through with farm plans	Probably no change	Supported no change
Competitions, awards & prizes	Not used	Slight increase in use; at the time, the Council was considering this instrument	Supported a slight increase
Financial assistance	*Chose not to distinguish between financial incentives and assistance*	*Chose not to distinguish between financial incentives and assistance*	*Chose not to distinguish between financial incentives and assistance*
Regulation	Used, but acknowledged that the Soil Plan is fairly permissive in having only 4 rules; regulation seen as a backstop to activities with significant envir. impact	No significant changes foreseeable	Supported no change
Tradable rights & duties; consent bundles	Not used	Potentially a slight increase; were considering the idea of consent bundles linked with farm plans	Supported the idea of consent bundles, but recognised their use would be limited by farmers not knowing their future consent needs
Covenants	Minor use; integrate with QEII Trust	Slight increase in use due to a greater interest in biodiversity protection	Supported a slight increase
Management agreements	Minor use	Possibly a slight increase if the concept of consent bundles was adopted	Supported a slight increase
Education to assist	Major use afforded through direct liaison with farmers	No change	Supported no change
Education for promoting & encouraging	Used; distinguished as environmental education focusing on schools, the public, and mass audiences	Slight increase	Supported a slight increase; acknowledged the Council had been historically light on public & school dimensions of environmental education

Table 2.17: Wellington Regional Council usage of general instruments for promoting SLM.

Working with farmers was also emphasised as the extensive use of one-to-one consultation associated with farm visits (Table 2.18). This may be supported in the future with a greater use of DIY type kits, particularly as they relate to the Visual Soil Assessment guide, and to the self-assessment of land afforded through the Soils Underpinning Business Success program (Wellington RC are currently applying the SUBS programme as a pilot – see Chapter 7). The provision of information receives only minor use, although this is offset somewhat by the depth of expertise available for extension and education purposes.

One final feature peculiar to the Wellington RC is the use of true community groups, as opposed to issue-based interest groups (coast-care, Landcare, etc.). These were described as geographical communities based on residual catchment schemes (*i.e.* from the era of catchment boards), with a problem particular to their catchment community (flooding, erosion, willow congestion, road maintenance). Each has it's own rating scheme, and an advisory committee to delegate investment in works required. Council matches a community's financial contribution, and will put forward an annual works programme that requires committee approval. There are six of these community catchment schemes operating in the Wellington Region.

	Current use	**Probable change in use**	**Preferred change in use**
Promotional material	Minor use	Slight increase in use	Supported a slight increase
Fact sheets & info packages	Minor use	Slight increase in use	Supported a slight increase
DIY kits	Minor use	Perhaps a shift to considerably more use with the introduction of VSA, and an interest in the SUBS programme	Supported considerably more use
Farm visits (1 to 1 consultation)	Extensively used	No change	Supported no change
Focus farms	Used; actively involved with MRDC monitor farms; includes the provision of a sustainability plan for the farm	No change	Supported no change; hadn't received a high degree of positive feedback from involvement in focus farms
Field days	Minor use	No change	Supported no change: 'you can invest a lot of time in field days but get very little gain in return'
Farmer discus-sion groups	Used; integrate with industry discussion groups on a monthly basis	No change	No change
Landcare groups	Minor use	Possibly a slight increase driven by public interest and policy shifts from the central office	Supported a slight increase in some areas of SRM, but not for soil conservation
Other com-munity groups	Used; work with catchment scheme advisory committees	No change	Supported no change
Regular publications	Used; persons involved with catchment schemes receive an annual newsletter; also includes the *Elements* newsletter that goes out to all ratepayers	Slight increase in use	Preferred no change

Table 2.18: Wellington Regional Council usage of extension/delivery methods for promoting SLM.

2.5.10 Tasman District Council

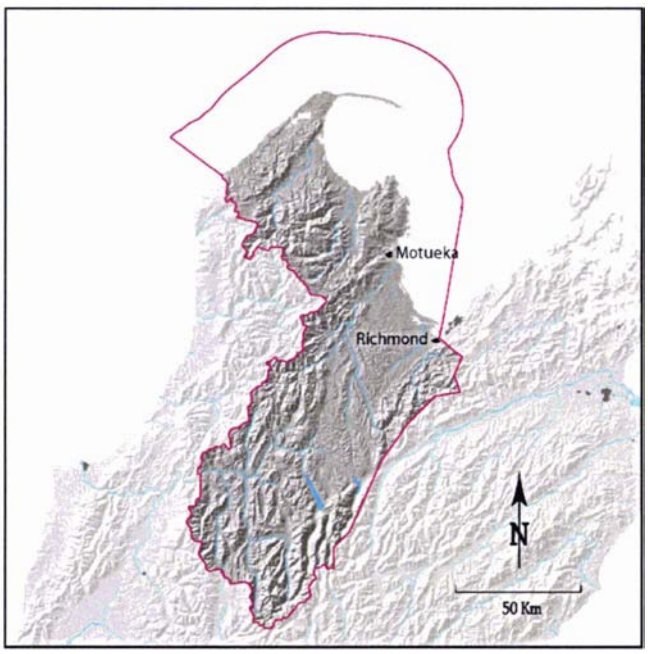
After the passing of the Local Government in 1987, administration for the top quarter of the South Island was initially under the Nelson-Marlborough Regional Council. This organisation was disestablished in 1992, and it's responsibilities distributed between three new unitary authorities – Tasman District, Marlborough District, and Nelson City councils. Tasman and Marlborough share similar statistics, including populations of around 40 thousand, and land areas close to one-million hectares. Tasman has a slightly smaller coastal area to manage (0.5m ha *cf.* 0.7m ha), and a lower revenue.

As a unitary authority, the TDC receives a modest revenue of $40m ($6m below the national median and $14.8m below the average) for carrying out both regional and district responsibilities. Native vegetation dominates land cover (approximately 60% of the district is part of the crown conservation estate), although areas of agriculture and forestry are significant. SLM issues are similar to those of other regions, although there are increasing problems relating to intensification of the District's limited area of more versatile land (particularly land fragmentation, water quality decline, and increasing competition for water allocation).

The TDC has a massive Resource Management Plan (TDC, 2002), which acknowledges four relevant methods of promoting SLM: advocacy & education; works & services; financial methods; and regulation. No singular preferred method could be identified from either the Plan or the RPS.

The person responsible for the Council's SLM programme (Colin Michie) was working to a tight schedule on the day of the interview. As such, most responses were curt, and not discussed in detail (this interview took the least amount of time relative to all other council interviews).

TASMAN DISTRICT COUNCIL SUMMARY



AREA: *0.95 million ha of land* & 0.49 million ha of coastal waters*

POPULATION: *40,036*

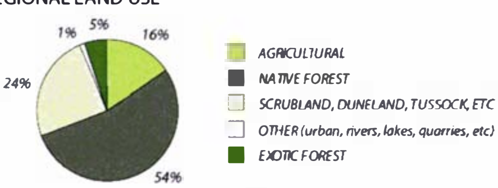
REVENUE: *$39.93 million (2002)*

EXPENDITURE: *$39.01 million (2002); $4.73m Resource Mgt & Policy*

SLM-RELATED ISSUES (from RPS):
- *Sustaining land capability; land fragmentation & loss to urban growth*
- *Natural & heritage features of land; transboundary land use conflict*
- *Soil & water degradation (incl. contamination); pests & weeds*
- *Water allocation; water quality (contamination, ecosystems, gravel extraction, riparian, etc.)*

RELEVANT PLAN STATUS
- *Tasman Resource Management Plan (proposed) (combined Regional Plan for coast and land resources)*

REGIONAL LAND USE*



** Derived from NZLRI (see Appendix 3)*

Figure 2.18: General summary for Tasman District Council.

In a specific context of SLM, the Council's dominant approach was described as 'a blend of technical assistance tied with strong regulatory backdrops'. This is reflected in the degree of instrument use (Table 2.19) where regulation is afforded a status of major use, while the provision of technical services receives extensive use. Like many other councils, regulation is regarded as a necessary means for protecting the so-called 'environmental bottom line', although this line may be a little higher for the Tasman District (a reason for this was not given). Regulation may decrease in the future, particularly if resource-users continue to become more adept at contesting and challenging proposed rules (*i.e.* as submissions to the proposed Resource Management Plan).

	Current use	**Probable change in use**	**Preferred change in use**
Financial incentives	Minor use – see financial assistance below	No change	Supported no change
Financial disincentives	Not used for SLM; minor use for SRM as a charge on gravel extraction	Perhaps a slight decrease in use	Would support a slight decrease
Technical services	Extensively used, including farm plans	No change	Supported no change
Competitions, awards & prizes	Minor use; had just reinstated a generic environmental awards scheme	No change	Supported no change
Financial assistance	Minor use; includes a modest grants scheme (≈$200,000/yr) for 'rivers and soil conservation'	No change	Supported no change
Regulation	Major use	Perhaps a slight increase in use	Would prefer no change
Tradable rights & duties	Minor use; had also considered a water rights scheme	Perhaps a slight decrease in use if a water rights scheme was developed	Would support a slight decrease
Covenants	*Did not indicate current use*	*Did not indicate any change in use*	*No preference given*
Management agreements	*Did not indicate current use*	*Did not indicate any change in use*	*No preference given*
Education to assist	Used; had just employed a full time education officer	Slight increase	Supported a slight increase
Education for promoting & encouraging	*Chose not to distinguish educational assistance from promotion & encouragement*	*Chose not to distinguish educational assistance from promotion & encouragement*	*Chose not to distinguish educational assistance from promotion & encouragement*

Table 2.19: Tasman District Council usage of general instruments for promoting SLM.

The extensive use of services was supported by a modest grants scheme targeting river control and soil conservation (approximately $200,000 per year), and a major use of farm visits and one-to-one consultation (Table 2.20 overleaf). Information provision was 'used' in a similar context, while DIY kits and integration with farmer-based discussion groups was described as 'minor use'. In following with a strong one-to-one assistance theme, the interviewee would prefer to see a greater use of these three instruments.

	Current use	Probable change in use	Preferred change in use
Promotional material	Used	Slight increase	Supported a slight increase
Fact sheets & info packages	Used	Slight increase	Supported a slight increase
DIY kits	Minor use	Slight increase	Supported a slight increase
Farm visits (1 to 1 consultation)	Major use	No change	Supported no change
Focus farms	Used	No change	Supported no change
Field days	Minor use	No change	No change
Farmer discussion groups	Minor use	No change	Would prefer a slight increase
Landcare groups	Minor use	No change	Supported no change
Other community groups	Minor use	No change	Supported no change
Regular publications	Not used	Slight increase	Supported a slight increase

Table 2.20: Tasman District Council usage of extension/delivery methods for promoting SLM.

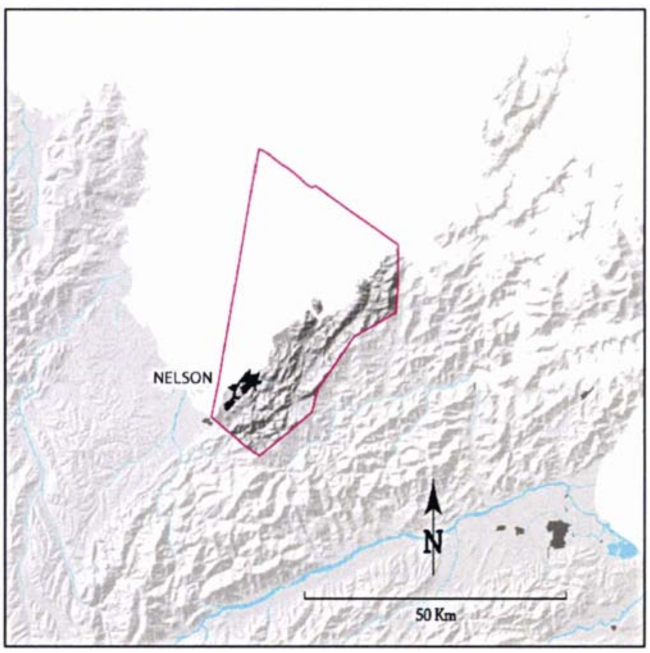
2.5.11 NELSON CITY COUNCIL

Nelson is New Zealand's smallest region at 43 thousand hectares (about 1.4% of Southland's land area), but has the second largest population density (≈ 1 person/ha). Revenue is $51.4 million ($5.4m above the median and $3.4m above the mean), although this is distributed between regional, district and city council responsibilities. The combined area of tussock and agriculturally-used land (Figure 2.19) suggests farming is a significantly large land use activity, although the RPS states that forestry now covers an area similar to that in indigenous forest (NCC, 1997). SLM issues are perhaps similar to those of Marlborough and Tasman, albeit on a much smaller scale.

Two Council representatives were interviewed: Paul Sheldon responded to the policy instrument component of the questionnaire, while Don Ballagh helped with questions concerning farm plans. Because of the Council's stage of developing a SLM programme, the first part of the interview was not undertaken according to the questionnaire framework.

Nelson City Council's overall approach to the promotion of SLM is difficult to interpret from policy and planning documents. While resource management is barely acknowledged in the Council's early draft Strategic Plan (NCC, 1996), it is later afforded the status of a 'significant activity' in the Long Term Financial Strategy (NCC, 1998). This activity broadly covers a number of functions (such as RM planning, consent processing & monitoring, pest management), and groups non-regulatory methods as the 'general promotion of good environmental management' (p.298). However, compared with regulatory approaches, the Strategy at the time acknowledged that non-regulatory methods (namely education & advocacy) were being 'carried out at a relatively low level at the moment' (p.299).

NELSON CITY COUNCIL SUMMARY



AREA: 43,050 *ha of land* & 66,200 ha of coastal waters*

POPULATION: *42,034*

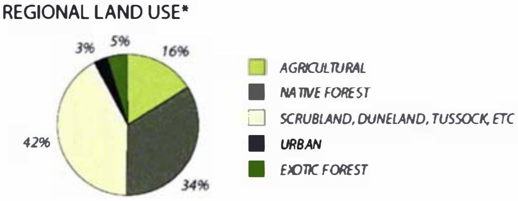
REVENUE: *$51.4 million (2002)*

EXPENDITURE: *$40.5 million (2002); $1.87m Resource Mgt.*

SLM-RELATED ISSUES (from RPS):
- *Management of weeds & pests; riparian & coastal margins; river/lake beds; natural areas with signf. amenity, conservation or landscape value*
- *Water quality & allocation*
- *Soil sustainability (erosion, quality, impact on water; versatile soils)*

RELEVANT PLAN STATUS
- *Resource Management Plan (proposed) [represents a combined District & Regional (coastal & land disturbance only) Plan]*

REGIONAL LAND USE*



** Derived from NZLRI (see Appendix 3)*

Figure 2.19: General summary for Nelson City Council.

Despite this acknowledgement, the Council proposed a greater emphasis on non-regulatory approaches in the future. For 'land and water care', the Council expressly proposed to "work on a one-to-one basis with all the rural landowners… to assist them in caring for land and water resources... [the Council] will encourage the formation of land and water care groups as well as the development of individual 'property plans" (p.304). However, subsequent progress in promoting 'good environmental management' appears to have been limited. Each successive Annual Plan tends to reiterate the Council's intention to 'develop a strategic approach to promoting environmental management' (NCC, 2001, p.45) through non-regulatory measures, but the parallel series of Annual Reports consistently fails to report any significant progress in rural RM. Without a meaningful non-regulatory SLM programme, regulation by default must represent the Council's overall approach to the 'promotion' of SLM.

This was tentatively acknowledged during the interview, although it was also emphasised that the Council had actively been working towards the introduction of more non-regulatory methods: 'in recent years… the Council now recognises that there needs to be a balance of regulatory and non-regulatory methods… and they've voted some funding for those non-regulatory methods… we have made some major progress in the last two years… but watch this space'. In a formal sense, this progress has involved working with Landcare groups (2-3 within the Nelson area), QE II National Trust, and the occasional allocation of grants for protection of significant natural areas. Further, because Nelson has so few farmers (many of which the staff know on a first-name basis), the Council can cultivate a somewhat unique liaison with land-holders, through which assistance, education and other non-regulatory tools can be applied informally on a farm-by-farm basis.

Considerable effort was also being invested in developing the concept of *property plans*. Indeed, the greater part of the interview was given to explaining and discussing this new tool. Because they represent a form of farm planning (albeit far removed from traditional models), property plans are examined in greater detail in Chapter 5. As a policy instrument, they can be described as a long-term negotiated agreement between a farmer and the Council, whereby a bundle of consents may be issued for ten-years or more if a farmer agrees to promote some dimension of on-farm sustainable management (particularly the protection of significant natural areas). Council pays for most of the process. Benefits to the farmer include reduced financial outlay and assurance/confidence in future land management and development. For the Council, regulation is effectively combined with a non-regulatory approach (as negotiated agreements & cooperation); on-farm RM issues can be identified, and a binding commitment to address issues can be obtained; and the conventional *ad hoc* approach to the consent process is replaced with a longer-term, whole-farm type of system.

The Council committed itself to the development of property plans in the proposed (regional) Resource Management Plan (NCC, 2000). At the time of the interview, development of the concept was entering a pilot phase, whereby a local farm with an agreeable manager had been targeted for a trial. Soon after, a meeting was held between the Council, Federated Farmers, and the local farming community, to finalise the details of a pilot farm. However, farmer opinion had changed significantly since the property plan concept had initially been put forward (by the farmers themselves), and they indicated that they no longer wished to proceed with the project (Paul Sheldon, 16 July 2002, per. comm.). Project funding was redirected at assisting landowners to protect or manage areas of conservation significance, and the concept of property plans was shelved.

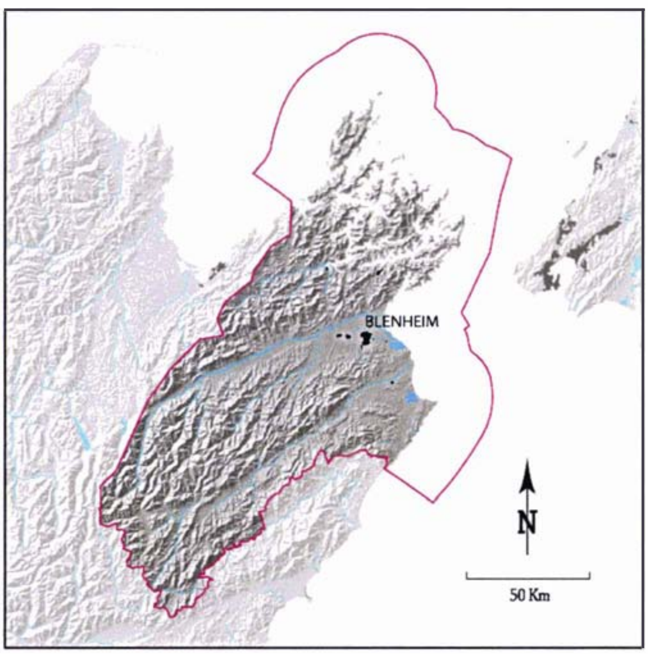
2.5.12 MARLBOROUGH DISTRICT COUNCIL

Marlborough District Council (MDC) administers a land area of 1.1 million hectares, divided into two parts for management under two respective Regional Plans. Population density is low at 0.4 people per hectare, while a revenue of $57.8 million is $11.8m above the national median and $3.0m above the mean. The NZLRI suggests agricultural use of land is modest at 24% of total area (Figure 2.20), although this does not account for the large expanse of farmed tussock-land in the high country. SLM issues are similar to those being experienced by Tasman District Council, particularly in regard to lowland intensification and it's relation to the modification and quality of surface waters, abstraction of groundwater for irrigation, and land fragmentation. Soil erosion appears to receive a low degree of emphasis, particularly in the RPS (MDC, 1995a).

The Council's dominant approach to the promotion of SLM is not explicitly stated in either the RPS, the Marlborough Sounds Resource Management Plan (MDC, 1995b), or the Wairau/Awatere Resource Management Plan (MDC, 1997). However, implementation methods for RPS policies are brief and frequently repeated. Policies concerning surface & groundwater, indigenous ecosystems, and soil integrity, all share the principal methods of regulation (mainly as rules) and education (as targeted education programmes to provide information). Protection of indigenous ecosystems is distinguished by a method involving collaboration with other agencies (namely the Dept. of Conservation and the QEII Trust).

Two people were interviewed from the Marlborough District Council (Nicki Eades & Ian Shadcock). It was explained that the Council had retained a strong territorial focus since establishment in 1992, and had only recently begun to emphasize the land management dimension of their regional responsibilities. Consequently, MDC's SLM programme is comparatively underdeveloped when considered against most other regional authorities. This has implications regarding the Council's overall approach to the promotion of SLM.

MARLBOROUGH DISTRICT COUNCIL SUMMARY



AREA: *1.06 million ha of land* & 0.70 million ha of coastal waters*

POPULATION: *40,242*

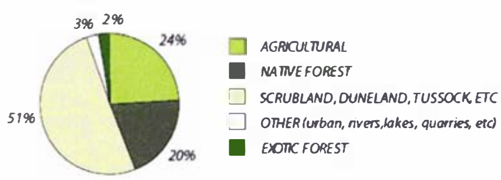
REVENUE: *$57.79million (2002)*

EXPENDITURE: *$47.16 million (2002)*

SLM-RELATED ISSUES (from RPS):
- *Protection of water ecosystems*
- *Protection of land ecosystems*
- *Protection of visual features*
- *Control of waste*

RELEVANT PLAN STATUS
- *Marlborough Sounds RM Plan (operative)*
- *Wairau/Awatere RM Plan (proposed)*
- *Marlborough RM Plan - Land Disturbance Control (operative)*
- *Wairau River Floodway Management Plan (operative)*

REGIONAL LAND USE*



** Derived from NZLRI (see Appendix 3)*

Figure 2.20: General summary for Marlborough District Council.

While controls on land use and related activities are considered minor, the previous absence of a distinguishable SLM programme has meant that regulation (tempered with an education programme) has been the Council's default overall approach. However, with a new emphasis on land management, regulation is now described as being an environmental backstop, and other approaches are being more strongly endorsed (education/provision of information, promotion/advocacy, and support/assistance). Despite this shift, resourcing is still a major bottleneck to the development of the Council's land management programme (only one staff member is employed explicitly in this area).

This situation is reflected in the degree of instrument use (Table 2.21). Key instruments include regulation and education, but the use of services, financial incentives/assistance, awards and covenants is likely to increase in the near future. An even greater use of these instruments was supported, but limited by the current level of resourcing. Consideration of more sophisticated instruments is unlikely, due to not only the stage of development of the SLM programme, but also because many instruments 'sound good in theory', but can be difficult to put into practice.

	Current use	**Probable change in use**	**Preferred change in use**
Financial incentives	Not used	Possible slight increase; had just developed a generic community grants scheme	Supported an increase
Financial disincentives	Not used directly	No change	Supported no change; the concept is attractive in theory, but would be difficult to implement in reality
Technical services	Minor use: "we are a small council.. we don't have a SLM team... I am the land management team"	Increased use; effectiveness will also increase as more people become aware of it	Supported increased use
Competitions, awards & prizes	Used; biennial 'rural environmental award'	No change	*No preference given*
Financial assistance	*Did not distinguish financial assistance from incentives*	*Did not distinguish financial assistance from incentives*	*Did not distinguish financial assistance from incentives*
Regulation	Used as a backstop; perhaps a higher use for forestry land use (*cf.* pastoral)	No change: 'I can't see it increasing'	Supported no change; recognised the necessity of regulation, and its effectiveness for creating change
Tradable rights & duties	Not used	No change	Supported no change: "I think the idea's good but difficult to put into practice"
Covenants	Minor use; integrate with QEII	Increased use	Supported increased use
Management agreements	*Current use not indicated*	*Possible change not indicated*	*No preference given*
Education to assist	Used: 'we provide education through information and technical services'	No change: "we would certainly like to do more but again we're a small council with limited resources"	Would prefer a slight increase
Education for promoting & encouraging	*Chose not to distinguish educational assistance from promotion & encouragement*	*Chose not to distinguish educational assistance from promotion & encouragement*	*Chose not to distinguish educational assistance from promotion & encouragement*

Table 2.21: Marlborough District Council usage of general instruments for promoting SLM.

The relation between limited resourcing and programme development is also reflected in the use of extension and delivery methods (Table 2.22). Most methods receive minor use, with further use being limited by resourcing. The interviewees supported increased use of almost all methods. Landcare groups are perhaps the most likely to increase, due to their autonomy and support from other agencies.

	Current use	**Probable change in use**	**Preferred change in use**
Promotional material	Minor use	Potential increase (depending on resourcing)	Supported increased use
Fact sheets & info packages	Minor use	Potential increase (depending on resourcing)	Supported increased use
DIY kits	Minor use; monitoring stream health	Potential increase (depending on resourcing)	Supported increased use
Farm visits (1 to 1 consultation)	Minor use in specific contexts; possibly a major use in pest control	*Did not indicate probable change in use*	Supported increased use
Focus farms	Not used	*Did not indicate probable change in use*	*No preference given*
Field days	Minor use	Potential increase (depending on resourcing)	*No preference given*
Farmer discussion groups	Minor use; will integrate with existing groups if invited	Potential increase (depending on resourcing)	Supported increased use
Landcare groups	Minor use: "its something that's getting up and running…"	Likely to increase	*No preference given*
Other community groups	*Did not distinguish from Landcare type groups*	*Did not distinguish from Landcare type groups*	*Did not distinguish from Landcare type groups*
Regular publications	Not used directly, but have regular newspaper articles	Probable increase in use (depending on resourcing)	Supported increased use

Table 2.22: Marlborough District Council usage of extension/delivery methods for promoting SLM.

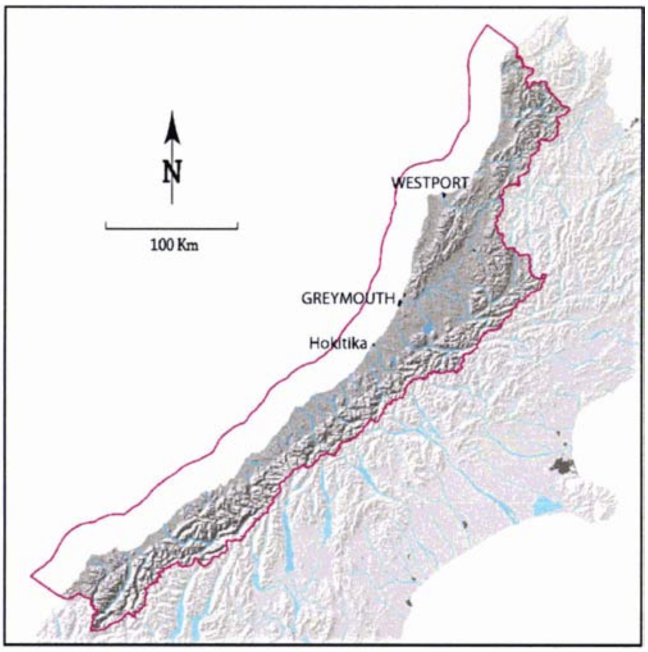
2.5.13 West Coast Regional Council

The West Coast[5] is New Zealand's fifth largest region at 2.35 million hectares, most of which is covered by indigenous vegetation (78% is managed as conservation estate). Only 21% of the land area is rateable, which coupled with a very low population density (0.02 people/ha), contributes to a humble revenue of $6.2 million. This is well below the national mean (-$40m) and median (-$48.6m), making it the lowest revenue of the 12 regional councils.

The area of land used for agriculture is relatively small (Figure 2.21), concentrated mainly into valleys and flat coastal areas of alluvial outwash. Rivers are notably short with a high rate of recharge, while many of the Region's lowland soils have impeded drainage (namely Recent Gleys, Organic Soils, Podzols and *pakihis*). As a general statement, SLM issues may be less prevalent relative to many other regions, particularly in relation to water quality and public concern/priority. However, specific issues highlighted during the interview included point-source discharges of dairy effluent, impacts on aquatic ecosystems associated with surface drainage ('humping and hollowing'), and issues related to flood control and streambank erosion.

The Council's overall approach to SLM is to 'use promotion where possible, in preference to the application of service delivery, regulation or economic instruments' (WCRC, 2000, p.17). Promotion is interpreted to include advocacy, education and the provision of information. However, low resourcing for 'promotion' across an extensive region, coupled with a high number of rules relating to agriculture (*e.g.* 12 of the 28 rules in the Regional Plan for discharges to land are explicitly related to agriculture), suggests regulation may be used to a degree higher than that implied in the RPS.

WESTCOAST REGIONAL COUNCIL SUMMARY



AREA: *2.35 million ha of land* & 1.27 million ha of coastal waters*

POPULATION: *35,639*

REVENUE: *$6.2 million (2002)*

EXPENDITURE: *$5.5 million (2002)*

SLM-RELATED ISSUES (from RPS):
- *Erosion; impact of land use on soil sustainability*
- *Impact on river beds & banks*
- *Change in water flows & volumes; water quality*
- *Ecosystem & biodiversity decline; loss of natural character;*

RELEVANT PLAN STATUS
- *Regional Plan for Discharges to Land (operative)*
- *Soil Conservation & Erosion Control Plan (proposed)*
- *Land & Riverbed Management Plan (draft)*

REGIONAL LAND USE*

* *Derived from NZLRI (see Appendix 3)*

Figure 2.21: General summary for West Coast Regional Council.

[5] Some of the diagrams presented in this chapter incorrectly use the title 'Westcoast' in place of the correct 'West Coast'.

The two interviewees (Trevor James & Rod Thornton) were able to clarify the Council's overall approach. From the outset of policy development, the WCRC had preferred the use of promotion as a means to raise awareness and understanding amongst the farming community. This involved extensive use of field days, newspaper articles, newsletters and other promotional material. However, towards the mid-1990s, concern was expressed that promotion was not having the desired effect, and the use of regulatory methods were considered in more detail. A shift to a greater use of regulation came in the late 1990s (with the employment of an additional three staff), and has gradually increased with the development of regional plans and the consolidation of a consents system. While promotion/education is still definitely used, the Council's overall approach appears to have skewed more towards regulation 'in the last few years'. This was summed as an opinion – 'regulation is the key; education [is] not effective'.

The use of regulation is reflected in the degree of instrument use (Table 2.23), whereby it was described as having a major use overall, and an extensive use for dairying. This was also related to the major use of financial disincentives, through costs associated with consents, abatement notices and infringement fines. The provision of services was also acknowledged as a major use, and linked alongside education and advice as a component of promotion. The Council does not provide any financial incentive/assistance in the form of grants, although it had been considered for riparian management on selected farms.

	Current use	**Probable change in use**	**Preferred change in use**
Financial incentives	Not used	No change	Would like a slight increase for riparian management
Financial disincentives	Major use, but only as a component of regulation	No change	No change
Technical services	Major use; will provide advice & information; may help farmers design more sustainable systems; will help with the consent process	No change	Would prefer a slight increase
Competitions, awards & prizes	Used; an environmental award had just been established	Possibly a slight increase	Supported a slight increase
Financial assistance	*Did not distinguish between financial incentives and assistance*	*Did not distinguish between financial incentives and assistance*	*Did not distinguish between financial incentives and assistance*
Regulation	Major use overall; extensive use for dairying	One respondent indicated no change, while the other indicated a slight increase in use	Would like to see a slight increase in some areas, on the basis that if no change results from a high investment of effort, then regulation may be necessary
Tradable rights & duties	Not used	No change	Supported no change
Covenants	Not used	No change	Supported no change
Management agreements	Not used	No change	Supported no change
Education to assist	Used	Slight increase	Supported a slight increase
Education for promoting & encouraging	Major use	Slight increase	Supported a slight increase

Table 2.23: West Coast Regional Council usage of general instruments for promoting SLM.

The use of other instruments is officially suggested by policy (namely rates relief, tradable rights & duties, and bonds), but this was not reflected in the degree of instrument use. Rather, as indicated during the interview, the Council would prefer to consolidate their primary SLM programmes before developing other alternative mechanisms (it was stated that some of the Council's SLM programmes are comparatively less evolved than those being used by other, better funded, regional authorities).

While responses from both respondents were agreeable for general use of instruments, they were less consistent for extension and delivery methods (Table 2.24), particularly in regard to the preferred change in use. To retain uniformity, preference has been given to reporting the senior officer's responses. Further, because of the flawed design of the questionnaire, the latter part of the interview was rushed and responses were curt.

The provision of information, field days and farm visits appear to be the Council's principal methods of effecting their SLM programmes. However, while this focus is likely to remain unchanged, a consistent preference for a greater use of other mechanisms was expressed. In particular, a preference for considerably more use of Landcare groups was stated, provided such groups could overcome the high degree of strong-willed individuality apparent in many West Coast areas.

	Current use	Probable change in use	Preferred change in use
Promotional material	Used	No change	Would like to see a slight increase
Fact sheets & info packages	Major use	No change	Preferred a slight increase
DIY kits	Used for water quality monitoring	No change	Preferred a slight increase
Farm visits (1 to 1 consultation)	Extensive use	No change	Supported no change
Focus farms	Not used	No change	Preferred a slight increase
Field days	Major use	No change	Supported no change
Farmer discussion groups	Not used	No change	Preferred a slight increase
Landcare groups	Minor use	No change	Preferred considerably more use
Other community groups	Not used	No change	Preferred a slight increase
Regular publications	Not used (no longer used)	No change	Preferred a slight increase

Table 2.24: West Coast Regional Council usage of extension/delivery methods for promoting SLM.

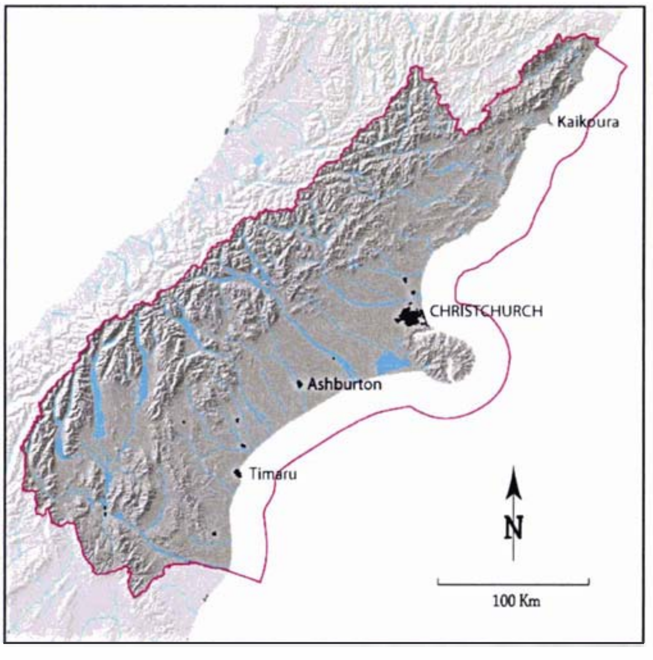
2.5.14 Canterbury Regional Council

Canterbury has the distinction of having the largest regional area at 4.5 million hectares, which encompasses land from four previous catchment authorities (North & South Canterbury Catchment Boards, Waitaki Catchment Commission, and part of Marlborough CB). Population density is low at 0.11 people/ha, while a revenue of $58.6m is $12.6m above the national median and $3.8m above the mean. Distinguishing SLM issues include high country erosion, and land use intensification particularly as it relates to water quality, water quantity/allocation, and wind erosion.

Preference for a singular policy instrument could not be identified from either the RPS (Ecan, 1998) or the Natural Resources Regional Plan (Ecan, 2001). Specific instruments for implementing 'soil and land use' policy include information provision, land owner/occupier groups, regulatory mechanisms, and 'advocacy, promotion and co-operation' (Ecan, 1998). Similar instruments are used for implementing other SLM-related policy, although water management has a distinguishing 'surveillance and enforcement' stated as a method of implementation.

The interviewee (Phil McGuigan) indicated that the overall method used to promote SLM involved a mix between advocacy, education and community partnership. While regulation is used as a backstop, a greater use was not considered as the best means of creating meaningful and lasting change in SLM. Rather, efforts are directed at stimulating a greater recognition of the links between activities and issues, on the basis that people need to understand the 'why' and 'how' as a precursor to change. In this sense, both advocacy and education are 'likely to bring about [the] connection and get the desired result, which will be more of a willingness to change rather than forcing people to change'. Community partnerships represent the principal mechanism through which education and advocacy are to be promoted.

CANTERBURY REGIONAL COUNCIL SUMMARY



AREA: *4.51 million ha of land* & 1.14 million ha of coastal waters*

POPULATION: *481,431*

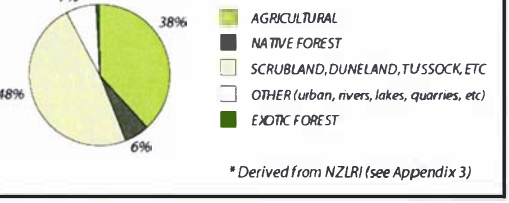
REVENUE: *$58.57 million (2002)*

EXPENDITURE: *$50.13 million (2002); $3.8 mill in 'land'; $6.2 mill in 'pest mgt.'; $8.8 mill in 'water quantity & quality'*

SLM-RELATED ISSUES (from RPS):
- *Land degradation (erosion, overcultivation, etc.), contamination & loss of versatile land*
- *Water quality & quantity; beds of rivers, lakes & their margins*
- *Integrity, character & contribution of natural areas*

RELEVANT PLAN STATUS
- *Natural Resources Regional Plan (proposed)*
- *Land & Vegetation Management Regional Plan (proposed)*
- *Regional Plans for Opihi & Waimakariri Rivers*

REGIONAL LAND USE*



** Derived from NZLRI (see Appendix 3)*

Figure 2.22: General summary for Canterbury Regional Council.

The Council's overall approach is supported by an extensive use of services, and a major use of education instruments (Table 2.25). Again, education is seen as a mechanism for promoting issue awareness and understanding, particularly as it relates to the relation between land use activities and environmental impact. This is implemented through the use of educational services and assistance targeting community groups.

Financial instruments were not used to any great extent. The reason for this was given as the resource-care group's limited funding, relative the number of SLM initiatives being implemented across the Region. However, a minor degree of funding is available through external sources – the Council will assist community groups with applications for environmental grants from a local Community Trust. The Council was also working towards establishing their own SLM funding programmes, specifically for promoting the protection of wetlands and biodiversity. The interviewee did not support a substantial grants programme, but did support a slight increase on the proviso that finances are used in a judicious and very targeted manner.

	Current use	Probable change in use	Preferred change in use
Financial incentives	Minor use	Slight increase in use	Supported a slight increase in use
Financial disincentives	Not used directly	No change	Supported no change
Technical services	Extensive use through community groups	No change	Supported no change
Competitions, awards & prizes	Minor use as a generic biennial Resource Management Award	Slight increase in use: the Resource Care section of the Council may consider SLM particular competitions	Supported a slight increase as competitions to encourage development of best management practices
Financial assistance	Minor use	Slight increase in use; currently seeking outside funding to support community groups	Would like to see a slight increase in use
Regulation	Used	Slight decrease in use	Supported a slight decrease in use
Tradable rights & duties	Not used	No change	Supported no change; considered that other instruments were more effective for inducing change
Covenants	Not used	Perhaps an increase in use	Supported increased use: 'they do have some advantages'
Management agreements	Not used	*No probable change in use given*	*No preference given*
Education to assist	Major use, with a particular emphasis on promoting understanding of an issue so a resource user can formulate *their own* solutions (*i.e.* high ownership)	Slight increase in use	Supported a slight increase in use
Education for promoting & encouraging	*Chose not to distinguish educational assistance from promotion & encouragement*	*Chose not to distinguish educational assistance from promotion & encouragement*	*Chose not to distinguish educational assistance from promotion & encouragement*

Table 2.25: Canterbury Regional Council usage of general instruments for promoting SLM.

The provision of promotional and factual information were considered together (Table 2.26), and afforded a status of major use. DIY kits were used, in the form of environmental kits for stream and soil monitoring. This also included 'environmental property kits', described as a checklist for identifying a broad conceivable range of environmental issues particular to individual farms. This is similar to Otago's Enviro-Ag, but without the same extent of detail for quality assurance. In doing so, it has an appeal to farmers who are not expressly interested in QA, but at the same time it can be used as a precursor to the Enviro-Ag programme if required. Likewise, it can also serve as a basis for the design of a farm plan (described as property plans).

Farm visits in a one-to-one context are not used: 'we have clear instructions from our councillors not to do one-one-one visits'. However, it was acknowledged that farmers may be engaged on an individual basis in certain situations, but certainly not to the same extent as some other councils. Farm visits were considered as an inefficient means of promoting SLM, relative to the extensive regional area that the Council is required to manage. In contrast, Landcare groups represent a means of engaging a number of people at the same place and time. Further, and perhaps more importantly, the community partnership system was proving to be an effective means of facilitating the Council's approach to SLM promotion (*i.e.* through education and advocacy).

	Current use	Probable change in use	Preferred change in use
Promotional material	Major use	No change	No change, provided the information remains relevant to the end user
Fact sheets & info packages	Major use	No change	No change, provided the information remains relevant to the end user
DIY kits	Used; described as environmental kits for soils & streams. Also includes 'environmental property kits'	Slight increase in use	Supported a slight increase in use
Farm visits (1 to 1 consultation)	Farm visits not used in a one-to-one context	No change	Supported no change
Focus farms	Not used	Slight increase; aim to integrate with MRDC monitor farms	Supported a slight increase; its 'the way to go… to go with industry'
Field days	Major use; includes televised field-days	No change	Preferred a slight increase in use; strongly supported field days on the proviso that 'you don't have too many and you're specific in what you're trying to achieve'
Farmer discussion groups	Not used	No change	No change; considered farmer discussion groups to be 'too focused' on the topics they prefer to deal with
Landcare groups	Extensive use; included other types of care groups (stream & beach)	No change	No change
Other community groups	*Chose not to distinguish other community groups from Landcare groups*	*Chose not to distinguish other community groups from Landcare groups*	*Chose not to distinguish other community groups from Landcare groups*
Regular publications	Major use; includes a bimonthly corporate newsletter, and a specific newsletter published in conjunction with Landcare Trust (twice every six months)	No change	Supported no change

Table 2.26: Canterbury Regional Council usage of extension/delivery methods for promoting SLM.

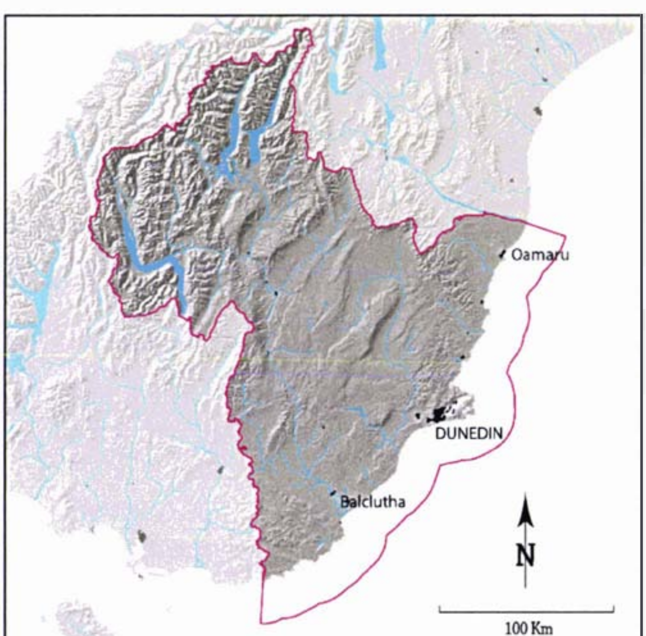
2.5.15 Otago Regional Council

Otago has the third largest regional area at 3.19 million hectares, which is only 1300ha smaller than Southland (according to the NZLRI and regional boundaries used in the 1996 census). However, it has the largest area of Crown owned land (ORC, 1998), most of which is tussock high-country leased for pastoral purposes. Like most South Island regions, significant areas of farmed tussock-land distort the percent of agriculturally-used land derived from the NZLRI (Figure 2.23). Population density is low at 0.06 people/ha, while a revenue of $46 million is very close to the national median (-$10,000) and mean (-$8.8m).

Historically, high country erosion and pest management (*e.g.* rabbits and hawkweed) have been significant SLM issues, but these have increasingly been overshadowed by issues associated with lowland intensification (particularly water quality and quantity), and the protection of lakes and rivers. Otago is one of the few regional authorities who do not have a land/soil plan (although the Regional Plan for water states that the Council is 'considering' such a plan).

The Council's overall approach to the promotion of SLM is suggested in the RPS: "sustainable management of Otago's resources requires that communities develop wise resource management attitudes, preferably through education rather than regulation. Cooperation of individuals... will provide regional as well as local benefits" (ORC, 1998, p.25). Other relevant instruments recognised in the RPS include the provision of information; works & services; advocacy (as 'encouragement'); negotiated agreements; incentives (financial or other); and economic instruments.

OTAGO REGIONAL COUNCIL SUMMARY



AREA: *3.19 million ha of land* & 0.67 million ha of coastal waters*

POPULATION: *177,000*

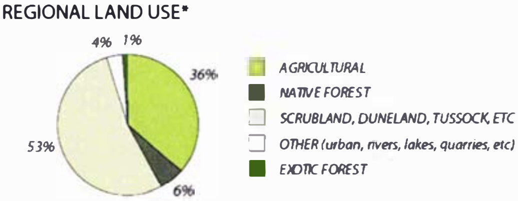
REVENUE: *$45.99 million (2002)*

EXPENDITURE: *$47.16 million (2002)*

SLM-RELATED ISSUES (from RPS):
- *Productive capability of land/soil (as threatened by land use, development, erosion, contamination etc)*
- *Integrity, character and values associated with natural features (incl. wetlands, riparian, lakes, etc.)*
- *Water consumption, allocation & availability; inefficient water use*
- *Ground and surface water qualtity*

RELEVANT PLAN STATUS
- *Regional Plan: Water (proposed)*
- *Regional Plan: Waste (operative)*

REGIONAL LAND USE*



** Derived from NZLRI (see Appendix 3)*

Figure 2.23: General summary for Otago Regional Council.

The person interviewed (Ian Brown), restated the Council policy as 'a strong emphasis… of working with farmers on a voluntary basis… [through] encouragement, facilitating, and educating'. However, in terms of what was actually being effected, the interviewee acknowledged that regulation is also a key approach by default: 'if we were just relying on education… we would never get the [desired] outcomes' with some people. Considered together, the Council's overall method is 'well balanced between education and regulation', and there is a 'strong emphasis of working with communities'.

This is reflected in the degree of instrument use (Table 2.27), where services, regulation and education were highlighted as being principal instruments. The provision of services is interlinked with education, particularly in relation to field days, workshops, farm planning and the provision of information and advice. The use of regulation had recently increased slightly in the area of compliance monitoring, while the long term effectiveness of education will determine the future use of regulatory approaches – 'if we go another 5-10 years… and the education side of things is clearly not working… then it might be necessary to take a closer look at regulation'.

	Current use	**Probable change in use**	**Preferred change in use**
Financial incentives	Minor use; have a grant for protecting wetlands	Probable increase in use	Supported increased use
Financial disincentives	Not used directly	No change	Supported no change
Technical services	Used	No change	Supported no change
Competitions, awards & prizes	Minor use: annual award	Likely to increase slightly	Supported a slight increase
Financial assistance	*Chose not to distinguish financial assistance from incentives*	*Chose not to distinguish financial assistance from incentives*	*Chose not to distinguish financial assistance from incentives*
Regulation	Used	Perhaps a very small increase	Supported a small increase
Tradable rights & duties	Not used	No change	Supported no change
Covenants	Not used	Perhaps a very small increase	Supported a small increase
Management agreements	Not used	No change	*No preference given*
Education to assist	Major use	No change	Supported no change
Education for promoting & encouraging	*Chose not to distinguish educational assistance from promotion & encouragement*	*Chose not to distinguish educational assistance from promotion & encouragement*	*Chose not to distinguish educational assistance from promotion & encouragement*

Table 2.27: Otago Regional Council usage of general instruments for promoting SLM.

An emphasis on education and community partnerships is reflected in the types of extension and delivery methods favoured by the Council (Table 2.28). In particular, field days are extensively used as part of a 'land issues information sharing' programme that has been operating since 1996 (Ross, 2000). Numbers of field days have been very high (93 held over 1996-98), but this number has been reduced to a more manageable target of around 20 field days per year. A high degree of information provision (fact sheets etc.) links in with the field day programme.

Another distinguishing feature is the use of collaborative group-related approaches, relative to a minor use of farm visits and associated one-to-one consultation. Group approaches are an efficient means of promoting SLM (the Council's Land Resources Section has only three or four staff to cover an extensive area). This includes working with established Landcare groups (approximately 30 groups distributed across the Region), group-based workshops (*e.g.* farm planning workshops), the North Otago Sustainable Land Management Group (NOSLaM), and integrating with various industry groups when possible (*e.g.* MRDC monitor farms, LIC farm discussion groups).

	Current use	**Probable change in use**	**Preferred change in use**
Promotional material	Used	No change	Supported no change
Fact sheets & info packages	Major use	No change	Supported no change
DIY kits	Minor use	No change	Supported no change
Farm visits (1 to 1 consultation)	Minor use	Possibly a decrease in use	Supported no change: 'I think the current balance is about right'
Focus farms	Used; integrate with 5 monitor farms throughout the Region	No change	Supported no change
Field days	Extensively used; approximately 20 field days per year	No change; 'we could maintain a level of 20 field days per year'	Would prefer less use
Farmer discus-sion groups	Minor use; integrate with some LIC discussion groups	Likely to increase in use in tandem with dairy expansion	Supported increased use
Landcare groups	Used; approximately 30 groups across Otago; integrate/assist existing groups rather than establishing them	No change	Supported no change
Other com-munity groups	Used	No change	Supported no change
Regular publications	Used; catchment & workshop based newsletters	Likely to increase in use	Supported increased use

Table 2.28: Otago Regional Council usage of extension/delivery methods for promoting SLM.

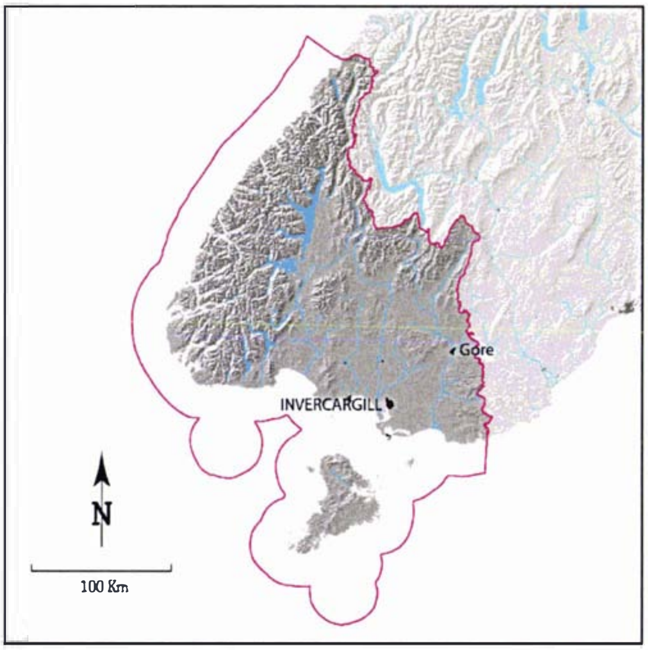
2.5.16 SOUTHLAND REGIONAL COUNCIL

Southland has the second largest regional land area in New Zealand (3.2 million hectares), and the largest coastal area (2.3 million hectares). Native vegetation dominates land cover (≈ 60%), although the area of agriculturally used land is significant (Figure 2.24). Revenue is low at $17.3 million, which is $28.7 million below the national median and $37.4 million below the mean. SLM-related issues are similar to those experienced by other councils, although pests may be comparatively less of a problem (because of the cooler climate). Further, extensive conversion and intensification of land in recent years (mainly relating to the dairy industry), has contributed to increased concerns regarding water quality and soil health.

The Southland RPS (SRC, 1997) provides a long list of methods available to the Council for implementing policy. Along with various regulatory mechanisms, those of relevance include: information, education & public awareness; promotion; advocating; protocols & accords (*e.g.* covenants); economic instruments; assistance; and works & services. None of these methods was singled out as the Council's overall and preferred approach to promoting SLM (note: Southland Regional Council do not have a 'land' or 'soil' regional plan).

The interviewee (Gary Morgan) indicated that the principal method used to promote SLM included services and assistance on a farm-by-farm basis. This was also described as one-to-one farm advice supported by education, advocacy and financial incentives/assistance. Despite having a large regional area, farm visits are considered viable because the majority of agriculturally-used land is concentrated within manageable areas (*i.e.* the Waimea and central Southland Plains; Mataura and Waiau Valleys; and the Te Anau/Manapouri Basin).

SOUTHLAND REGIONAL COUNCIL SUMMARY



AREA: *3.19 million ha of land* & 2.28 million ha of coastal waters*

POPULATION: *46,331*

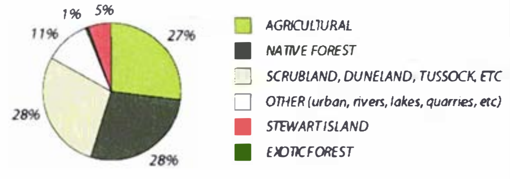
REVENUE: *$17.32 million (2002)*

EXPENDITURE: *$14.4million (2002); Land = $8.06 mill; Water = $4.4mill (catchment mgt = $3.1; biosecurity = $5.76; envr info = $1.6)*

SLM-RELATED ISSUES (from RPS):
- *Biodiversity*
- *Water quantity & quality*
- *Lakes, rivers & wetlands*
- *Soil degradation*
- *Landscape & natural features*
- *Waste management*

RELEVANT PLAN STATUS
- *Regional Solid Wast Plan for Southland (operative)*
- *Regional Effluent Land Application Plan (operative)*
- *Regional Freshwater Management Plan (proposed)*

REGIONAL LAND USE*



** Derived from NZLRI (see Appendix 3)*

Figure 2.24: General summary for Southland Regional Council.

The overall use and preference of services and assistance was strongly apparent in the degree of instrument use (Table 2.29). Financial incentives/assistance receives major use, primarily as a $50,000 fund available for promoting riparian management. This use is likely to increase in the medium term, as greater effort is directed at water quality protection through riparian management, particularly as it relates to ongoing dairy expansion. Being a self-described 'old school soil conservator', the interviewee would prefer an even greater use of this instrument: 'if you want to get things done… you can go out to farmers with a carrot… with some money… and get the work done'.

Similarly, the interviewee would like to see an even greater use of technical services. Presently this instrument is extensively used, particularly as it relates to the provision of advice and assistance, and the preparation of shelter and riparian management plans. While the degree of use is unlikely to change, the interviewee would like to see more Land Sustainability Officers employed (presently the Council has two), and established within the communities they would be servicing.

The Council presently favours education and advocacy over regulation. Education and advocacy receive major use through information provision and field days. Regulation is judiciously used as a backstop against persistent offenders, particularly as it relates to stock in water courses, silage stacks adjacent to water courses, feeding or wintering stock on river beds, and some industrial companies. However, the use of regulation may increase in the future, on the basis that resource-users have had considerable opportunity to become more aware and informed through ten years of advocacy and education programmes. Professing or feigning ignorance about SLM or environmental issues may no longer be considered as a valid argument against a greater use of regulation.

	Current use	Probable change in use	Preferred change in use
Financial incentives	Major use	Slight increase	Preferred considerably more use
Financial disincentives	Not used directly	Possibly a slight increase; Council had been considering forms of rates relief	Supported a slight increase
Technical services	Extensively used	No change	Would like to see an even greater use as more community-based staff
Competitions, awards & prizes	Used as an annual environmental award for SLM or land based operations	No change	Supported no change: 'its just another tool in the toolbox'
Financial assistance	*Chose not to distinguish financial assistance from incentives*	*Chose not to distinguish financial assistance from incentives*	*Chose not to distinguish financial assistance from incentives*
Regulation	Used as a backstop	Perhaps a slight increase as farmers become more informed through education & advocacy programmes	Supported a slight increase
Tradable rights & duties	Not used	Possibly a slight increase; consent bundles for dairy conversions had been considered	Supported a slight increase
Covenants	*Did not indicate current use*	*No probable change given*	*No preference given*
Management agreements	Minor use; farmers sign a binding 'minor works agreement' linked with Riparian Management Plans	Slight increase related to greater promotion of riparian management linked to ongoing dairy expansion	Supported a slight increase
Education to assist	Major use; 'we are quite strong on this one'	No change	Supported no change
Education for promoting & encouraging	*Chose not to distinguish educational assistance from promotion & encouragement*	*Chose not to distinguish educational assistance from promotion & encouragement*	*Chose not to distinguish educational assistance from promotion & encouragement*

Table 2.29: Southland Regional Council usage of general instruments for promoting SLM.

The present preference for advocacy/education over regulation is reflected in a high use of field days and information provision, and an interest in the further development of DIY kits and a SLM-specific newsletter (Table 2.30). Likewise, the dominant use of farm services/assistance is further expressed as an extensive use of farm visits on a one-to-one basis.

Approximately eight field days are held on an annual basis, and the Council will integrate with days held by the Farm Forestry Association. Similarly, staff will link into farmer-based discussion groups where possible, although this is usually on an annual basis as an invited speaker. The Council supports Landcare groups, and will provide assistance in terms of funding and administration (approximately 8-9 Landcare groups were operating in the Region at the time of the interview).

	Current use	**Probable change in use**	**Preferred change in use**
Promotional material	Used	No change	Supported no change
Fact sheets & info packages	Major use	Perhaps a slight increase	Supported a slight increase
DIY kits	Minor use; just beginning to use soil and water monitoring kits	Considerably more use	Supported considerably more use
Farm visits (1 to 1 consultation)	Extensively used	No change	Supported no change
Focus farms	Used	No change	No change
Field days	Major use	Slight increase	Supported a slight increase
Farmer discussion groups	Used	No change	No change
Landcare groups	Used	Perhaps a slight increase	Supported a slight increase
Other community groups	*Chose not to distinguish community groups from Landcare groups*	*Chose not to distinguish community groups from Landcare groups*	*Chose not to distinguish community groups from Landcare groups*
Regular publications	Used in the context of a generic region-wide newsletter	Slight increase	Would support a slight increase; interested in developing a SLM specific newsletter similar to that used by Gisborne

Table 2.30: Southland Regional Council usage of extension/delivery methods for promoting SLM.

2.6. SUMMARY AND DISCUSSION

2.6.1 SUMMARY BY COUNCIL

Northland: The stated overall approach to the promotion of SLM emphasised education over regulation. Council preference for education was given with a temporal proviso – if education fails to adequately promote SLM over the 10 year life of the regional plan, then the preference may shift to regulation. Principal individual policy-instruments used included education, the provision of services, and to a lesser extent, contestable grants. The use of grants, competitions/awards and covenants is likely to increase in the near future. Provision of information, community groups, and one-to-one farm visits dominated the extension & delivery type instruments. DIY kits and field days are likely to increase in use, along with a potential major-increase in the use of care groups. The interviewee's preferences were generally aligned with the Council's likely trends.

Auckland: Overall approach includes a combination of education and advocacy, although promoting the water dimension of SLM relies strongly on regulation. Education and the provision of services were highlighted as individual policy instruments that receive major use. Financial grants were not used to any great extent, despite the Council having one of the country's highest regional revenues. Provision of services and management agreements may increase in use if the Council readopts farm planning. Delivery & extension instruments were dominated by the provision of information and Landcare groups, followed by DIY kits, one-to-one farm visits, and field days. With the exception of one-to-one visits and the provision of factual (*cf.* promotional) information, all delivery/extension type instruments are likely to increase in use in the near future. Relative to Council's likely trends, the interviewee would prefer considerably greater use of grants and covenants, along with a slight increase in the use of competitions/awards and education.

Waikato: The Council's overall approach is strongly characterised by education and community partnerships, although this is underpinned by the use of a broad mix of instruments. Individual use of instruments is dominated by education and competitions/awards, followed by services, regulation, and covenants. Regulation is regarded as a necessary backstop that is likely to decrease in use. Grants, services, education and agreements (including covenants) are likely to increase in use, as a result of Council's emphasis on catchment schemes and the management of riparian and biodiversity resources. Extensive use of Landcare groups dominate delivery & extension instruments, followed by field days and the provision of information. Collective delivery/extension approaches are preferred because of the high number of small farm holdings distributed across the Region (although one-to-one visits are used in a low key manner). The provision of information, DIY kits, discussion groups, and support for Landcare groups was likely to increase. The interviewees' preferences were generally aligned with the Council's likely trends.

Bay of Plenty: The stated overall approach represents a balance between regulatory and non-regulatory methods, characterised by an emphasis on advice and assistance in the form of grants, services, and one-to-one liaison. Financial grants dominated the use of individual instruments, followed by services, competitions/awards, regulation, management agreements and education. Collective types of extension & delivery instruments receive a low degree of use (field days, Landcare groups), relative to a high use of one-to-one farm visits and the provision of factual information. One-to-one farm visits were considered as the most effective method of inducing on-farm change. The use of DIY kits was likely to increase, along with support for increases in Landcare groups. Relative to Council's likely trends, the interviewee would prefer considerably greater use of education, and a slight increase in the use of grants.

Gisborne: Regulation was unabashedly stated as the Council's dominant approach to the promotion of SLM. Justification was given as having limited resources for non-regulatory approaches, relative to the magnitude and difficulty of the District's SLM issues (namely erosion of pastoral hill country). However, as indicated with individual instruments, the major use of regulation is tempered with a major use of services and education. Use of regulation may also increase in the future. One-to-one liaison was highlighted as the principal extension/delivery method, followed by the Council's distinctive newsletter (Conservation Quorum) and occasional field days. Other than a slight increase in DIY kits, the use of most extension & delivery methods was unlikely to change in the near future. Because of previous failures in the District, Landcare groups were unlikely to increase. Relative to Council's likely trends, the interviewee would prefer considerably greater use of grants, regulation and management agreements, along with a slight increase in the use of competitions/awards.

Hawkes Bay: The Council's overall approach to the promotion of SLM is skewed towards non-regulatory methods, particularly as encouragement (advocacy and education) and assistance (grants, services, and one-to-one liaison). Minimal use of regulation has been ingrained in policy from the outset, and is used to protect the environmental bottom line. Future use of regulation may increase slightly in targeted areas of land use over the medium term, along with a possible long-term increase dependent on public and government pressure. A broad mix of individual instruments dominated use, including grants, services, agreements (including covenants) and education. Future use of all general instruments was likely to increase, particularly in regard to grants and covenants targeting a developing emphasis on biodiversity protection and management. Provision of factual (*cf.* promotional) information and one-to-one farm visits were highlighted as extensively used delivery & extension methods, followed by Landcare groups, field days, focus farms and DIY kits. The use of discussion groups and DIY kits was likely to increase, while the number of field days held per year was likely to decrease. The interviewee's preferences were generally aligned with the Council's likely trends.

Manawatu-Wanganui: Overall approach is similar to Hawkes Bay's, particularly with an emphasis on non-regulatory approaches characterised by advocacy and education, backed up with advice and assistance (grants, services, and one-to-one liaison). Regulation was not strongly pursued, but used as a backstop to protect the environmental bottom line. However, regulatory approaches were more dominant for water management, future use may increase in the area of water allocation. Individual policy-instruments dominated by a major use of grants and services, followed by the use of competitions/awards and education. Future use of education and grants is likely to increase, along with a potential introduction of tradable rights & duties for water management. One-to-one farm visits dominated extension & delivery methods, followed by DIY kits and the provision of factual (*cf.* promotional) information. Both were likely to increase in use, along with a greater use of farmer-discussion and community groups (as pest control groups). Relative to Council's likely trends, the interviewee disagreed with an increased use of grants and tradable rights & duties (the status quo was preferred).

Taranaki: The Council's overall approach is strongly non-regulatory, distinguished by having only one rule concerning land (but 87 rules for water), and an emphasis on the provision of information, advice and assistance through direct liaison. Grants are not used as an incentive or for assistance. Use of individual instruments was dominated by the provision of services and education (for assisting on a one-to-one basis), followed by covenants, management agreements, education (for promoting on a collective basis), and competitions/awards. The Council may increase it's use of education (for promoting on a collective basis) while decreasing competitions/awards. One-to-one farm visits dominated delivery & extension methods, followed by the provision of information and farmer discussion groups. Only the use of these discussion groups was likely to increase in the future. Relative to Council's likely trends, the interviewee would prefer no change in the use of education for promotional purposes, and a slight increase in the use of specific types of focus farms.

Wellington: The stated overall approach emphasised non-regulatory mechanisms, involving education and assistance through grants, services and direct liaison. Regulation is not used to any great extent in land management (only 4 rules in the regional soil plan), but considered necessary to protect the environmental bottom line. Use of grants was highlighted as the dominant individual instrument, followed by services and education for assistance (on a one-to-one basis), and then regulation and education for promoting (on a collective basis). Future use of competitions/awards, negotiated agreements (including covenants and consent bundles), and promotional education, were all likely to increase. Increased use of covenants was linked with a greater interest in biodiversity management and protection. Use of delivery & extension methods was dominated by one-to-one farm visits, followed by focus farms, discussion groups, catchment community groups, and regular publications. The provision of information, Landcare groups and regular publications were likely to increase, along with a considerably greater use of DIY kits (depending on the success of VSA and SUBS trials). Relative to Council's likely trends, the interviewee would prefer a greater use of grants (as a reinstatement to previous grant ratios), and no change in the use of regular publications.

Tasman: The Council's overall approach was described as a blend of assistance (as services, direct liaison, and grants to a lesser extent) tied with strong regulatory backdrops. As a reflection, the use of individual instruments was dominated by the provision of services, followed by regulation and then education. Regulation was highlighted as being necessary to protect the environmental bottom line, and may increase in use in the future. Education may also increase, while a minor use of tradable rights & duties may decrease. Extension & delivery methods were dominated by one-to-one farm visits, followed by the provision of information and focus farms. Future use of DIY kits, regular publications, and the provision of information is likely to increase. Relative to Council's likely trends, the interviewee would prefer no change in the use of regulation, and an increased used of farmer discussion groups.

Nelson: The overall approach to the promotion of SLM is primarily through regulation, due in part to the Council's stage of developing a non-regulatory SLM programme, and the priority afforded to regional (*cf.* territorial) responsibilities. Regulation was offset somewhat by working with other agencies (Landcare and QEII Trusts); the selective and occasional provision of grants; seminars; and the unique liaison Council staff can have with farmers (afforded through having a small number of regional farm holdings). Considerable effort was being directed at developing the concept of property plans, which would represent a merging of regulatory and non-regulatory approaches through negotiated agreement. However, this project was later abandoned, with associated funding being redirected as grants for the protection and management of on-farm biodiversity resources.

Marlborough: Regulation represented the Council's default overall approach to the promotion of SLM, but this was being ameliorated through the development of a non-regulatory SLM programme (reflecting a recent political shift in Council philosophy). However, the pace of development was being constrained through limited resourcing (reflecting priorities between territorial and regional responsibilities). As a default, regulation was considered as a necessary environmental backstop, and it's use was unlikely to increase in the foreseeable future. The use of individual instruments was dominated by regulation, education and a biennial rural environmental award. Future use of grants, services, and covenants was likely to increase. Apart from not using focus farms, all other delivery & extension methods receive a minor degree of use. Likewise, all could receive greater use in the future, although this was wholly dependent on resourcing. The interviewee's preference was for increased use of most instruments (the exceptions being regulation, tradable rights & duties, and financial disincentives), although this was given with a precaution that some instruments sound good in theory, but can be difficult to implement in practice.

West Coast: The Council's overall approach has recently trended towards the use of regulatory over non-regulatory approaches. The previous approach was dominated by education and advocacy (for increasing awareness & understanding in the farming community) underpinned by regulation. Concerns that education and advocacy were not having the desired effect resulted in a greater emphasis on regulation towards the late 1990s. The use of regulation may further increase in the future, particularly if a similar lack of progress is experienced in certain areas of land use. Relative to other councils, West Coast has a comparatively underdeveloped non-regulatory SLM programme, due in part to the new emphasis on regulation, and limited resourcing for an extensive regional area. The use of individual instruments was dominated by regulation, the provision of services (particularly in relation to assistance with consent processes), and promotional education (on a collective basis). This was followed by competitions/awards and education for assistance (on a one-to-one basis). Along with regulation, competitions/awards and both types of education were likely to increase in use. One-to-one farm visits represented the dominant delivery & extension method, followed by field days and the provision of information. No future change in the current use of extension & delivery methods was expected. Relative to Council's likely trends, the interviewees would prefer to see a greater use of grants (for riparian management) and services, and apart from one-to-one farm visits, would prefer a greater use of the majority of delivery & extension methods.

Canterbury: The stated overall approach was a mix of advocacy, education and community partnership, with regulation being acknowledged as a necessary backstop. Particular emphasis was given to raising SLM awareness and understanding, along with the provision of assistance to Landcare groups. Individual policy instruments were dominated by an extensive use of services (through community groups) and a major use of education, followed by the use of regulation. Grants (for wetland & biodiversity protection), competitions/awards, covenants, and education were all likely to increase in use, while the degree of use afforded to regulation may decrease. Delivery & extension methods were dominated firstly by support to Landcare groups, and secondly by the provision of information, field days, and regular publications. Collective approaches are strongly supported as an efficacious means of engaging a large number of farmers across Canterbury's extensive regional area. One-to-one farm visits are not supported to any large extent by the Council. Future use of DIY kits and focus farms is likely to increase. The interviewee's preferences were generally aligned with the Council's likely trends, although a single preference for increased use of field days was expressed.

Otago: The Council's overall approach was described as a balance between regulatory and non-regulatory approaches, with a strong emphasis on encouragement (advocacy), education, and assistance through community partnerships. Regulation is used in a low key manner, as a recognition that the use of non-regulatory approaches alone, may not result in the Council's desired outcomes. Like Northland, a temporal proviso for a possible increase in regulation was given if education fails to result in significant SLM progress over the next decade. Use of individual policy instruments was dominated by education (used on a collective basis), followed by the provision of services (also on a collective basis) and regulation. Grants and competitions were used in a very limited capacity, which along with covenants and regulation, were likely to increase in use. Delivery & extension methods were dominated by field days and the provision of information, followed by Landcare groups, focus farms, other community groups, and regular newsletters. One-to-one farm visits are not used to any great extent, as the Council considers collective approaches to be a more efficacious means of promoting SLM across the extensive Otago Region. Indeed, one-to-one farm visits may actually decrease in use, while the use of farmer discussion groups (particularly dairy groups) and regular publications may increase. Relative to Council's likely trends, the interviewee would prefer no change in the use of one-to-one farm visits, and less use of field days.

Southland: The stated overall approach emphasised non-regulatory mechanisms, involving education, advice and assistance delivered primarily through direct liaison. Regulation was judiciously used as a backstop against persistent offenders. Like Northland and Otago, the use of regulation may increase over the long-term, if non-regulatory approaches fail to achieve the Council's targeted RM outcomes. The use of individual instruments was dominated by the provision of services, followed by grants and education, and then regulation and competitions/awards. Grants, financial disincentives, regulation, tradable rights & duties, and management agreements, were all likely to increase in use over the next 5-10yrs. Extension & delivery methods were dominated by one-to-one farm visits, followed by the provision of information and field days. Other instruments were simply 'used'. DIY kits are likely to receive a considerably greater use in the future, alongside slight increases in the provision of factual (*cf.* promotional) information, field days, Landcare groups, and regular publications. Relative to Council's likely trends, the interviewee would prefer considerably more use of financial grants, and a greater use of service provision through the employment of additional staff.

2.6.2 Instrument Trends and Implications

Individual council results cannot be compared to those of other councils. Put another way, councils cannot be ranked or ordered according to the comparative degree of instrument use, as a means of identifying which councils make more or less use of a given instrument on a national basis. This is because the degree of use indicated by respondents was relative to their council's use of other instruments (*i.e.* not relative other councils' use of instruments). Hence, while two councils may indicate the same degree of use for a given instrument, differences in the development and resourcing of their respective SLM programmes may mean one council makes considerably more (or less) use of that instrument when compared on a national basis.

However, the suggested *emphasis* a council places on an instrument (relative to their entire combined mix instruments) can be compared between different councils. In numerical terms, this is akin to ascribing a percentage to the use of a single instrument, relative to the total use of all instruments by a council (*i.e.* 100%). In doing so, the *relative proportion of use* for a given council can then be compared to the *relative proportion of use* by other councils.

Unfortunately the nature of this study is not conductive to an objective application of the method described above. However, because respondents ascribed a given instrument's degree of use relative to their council's use of all instruments, then a proportional use can be inferred in a general and subjective manner. This has been achieved by plotting each council on a continuum according to the emphasis and proportional use of major individual instruments, as suggested by interviewees' responses. Plots are used as a basis for discussing trends and possible implications relating to major instruments.

2.6.2.1 General instruments

Financial incentives/assistance: The distinction between financial incentives and assistance was rarely made by the interviewees, with most preferring to refer to these instruments collectively as grants or subsidies. Eleven of the councils indicated a use of this instrument, although there was a wide range from large established grants schemes, to occasional and irregular allocation of monies on a case-by-case basis. The degree of use appeared to be related to resourcing for some councils (e.g. Wellington, Bay of Plenty, Marlborough, Westcoast), although two councils explicitly stated political and philosophical reasons for not making a significant use of grants (Auckland and Taranaki).

Wellington suggested the highest emphasis for the use of grants, followed by Bay of Plenty, Manawatu-Wanganui, and Southland (Figure 2.25). Ten of the fifteen councils indicated that the use of grants was likely to increase in the future, particularly in regard to the management of on-farm riparian and biodiversity resources. Although Nelson is not depicted (their responses were not discussed according to the questionnaire framework), they also suggested a greater use of grants for this purpose.

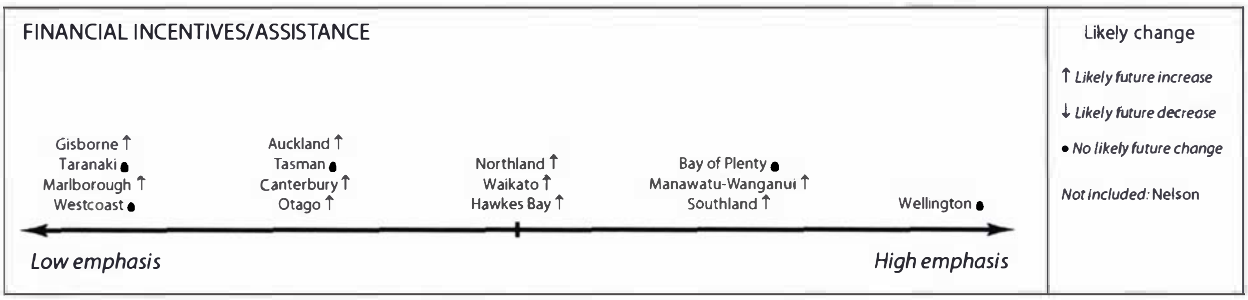


Figure 2.25: Individual council emphasis on present and future use of financial incentives/assistance as a means to promote SLM, relative to other councils.

Two principal implications can be linked with this trend. Firstly, there appears to be increasing support for grants as a mechanism to promote the management of privately-owned resources for the public good (namely riparian & biodiversity management). The implication being a slight 'back to the future' shift, whereby farmers are partially reimbursed for accommodating society's requirements and preferences for environmental management.

Secondly, councils establishing and implementing new policy regarding grants must accommodate answers to three fundamental questions: how are they going to pay for a grants scheme? How are they going to assess eligibility for grants fairly and equitably? And how are they to ensure that investment of public money is protected against individual misuse and pecuniary gain? An answer to the first question may involve either a reallocation of funding away from existing programmes, or perhaps a ratings increase. Answers to the second and third questions require a system of allocation and perhaps monitoring. Most councils with an already established grants scheme use farm planning as a means to allocate and monitor grants for individual farms.

Provision of services: All councils provide services as a means to promote SLM. The majority afford a high emphasis to the use of this instrument, and only four of the fifteen councils indicated a likely future increase of use (Figure 2.26). Other than Waikato, those who indicated a likely increase also gave provisos – Marlborough's use would increase if more resourcing was secured; Hawke's Bay's use would increase if an additional staff member was employed; and Auckland's use would increase if farm planning was readopted. Coupled with the overall high emphasis on this instrument, this suggests that most council organisations are reasonably content with their current levels of service provision.

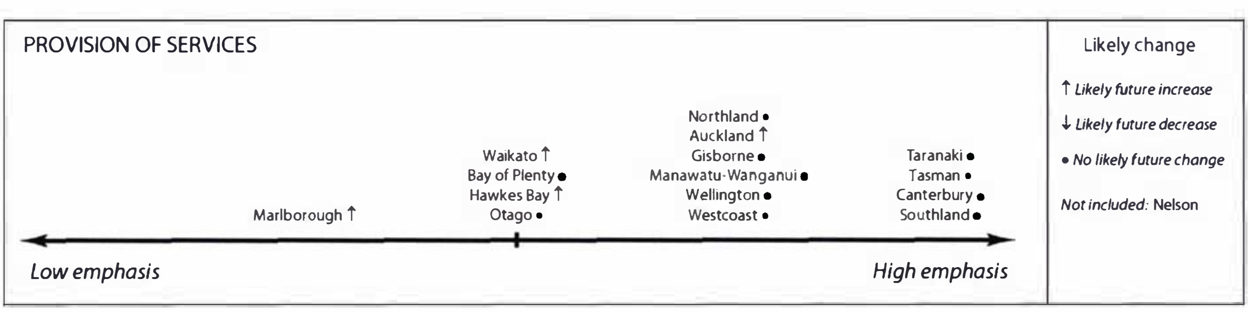


Figure 2.26: Individual council emphasis on present and future provision of services as a means to promote SLM, relative to other councils.

Financial disincentives: Most councils use financial disincentives indirectly as fines and penalties associated with regulation. For this reason, few councils chose to distinguish financial disincentives as a standalone instrument.

Competitions and awards: Use and support for competitions/awards varied widely. Most were either annual or biennial, with many being offered generically to a number of industry sectors (few councils had programmes specifically targeting SLM and farming). Some interviewees valued this instrument as an effective means of recognising and rewarding sound environmental management, while others regarded them as political tools for promoting the image of councillors and the council. Several expressed reservations about the widespread effectiveness of competitions, in that the same general groups of farmers repeatedly tend to dominate applications and eligibility.

Overall, councils appear to place a low to moderate emphasis on competitions and awards, with Waikato being the only council to suggest a high emphasis (Figure 2.27). All but two of the lower-emphasis councils indicated a likely future increase. This suggests that all councils are seeking to consolidate the use of competitions/awards within their overall SLM programme.

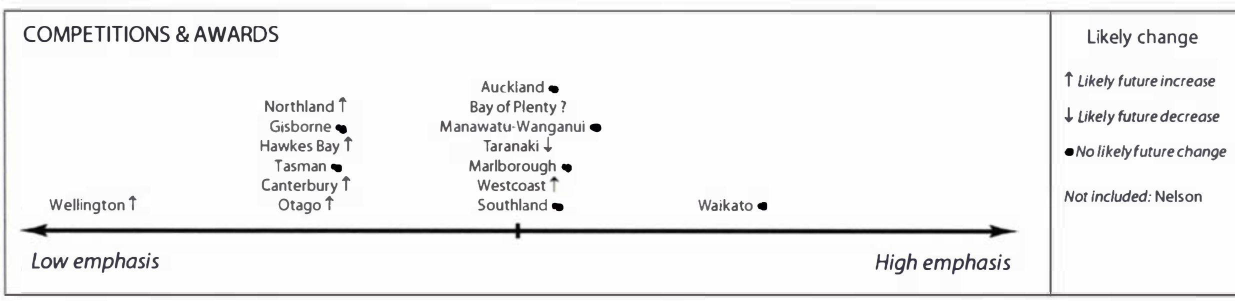


Figure 2.27: Individual council emphasis on present and future use of competitions & awards as a means to promote SLM, relative to other councils.

Regulation: Most councils suggested a moderate degree of emphasis on the use of regulation (Figure 2.28). The majority also indicated that regulation was used as a backstop to protect the environmental bottom line, and/or to control the blatant misuse of resources by repeating offenders. Several councils stated that regulation was used substantially more for water management, and less for land/soil management (Auckland, Manawatu-Wanganui, Wellington, Taranaki). Seven of the fifteen councils indicated a likely slight-increase in the use of regulation over the next 5-10 years, and four suggested a potential long-term increase if non-regulatory approaches prove to be ineffective. Associated implications are discussed later alongside overall approaches and trends (Section 2.6.2.3).

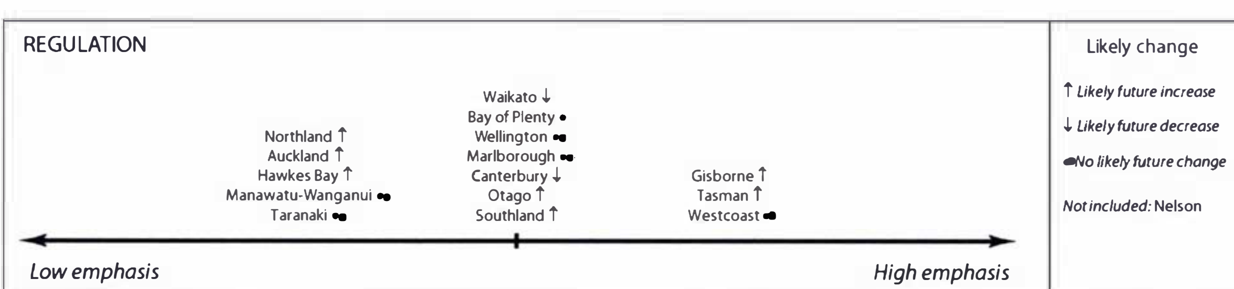


Figure 2.28: Individual council emphasis on present and future use of regulation as a means to promote SLM, relative to other councils.

Tradable rights and duties: Councils make very little use of this instrument for promoting SLM. Tasman was the only council to indicate any use, although the Bay of Plenty's strong links with constituent territorial authorities may convey an indirect and minor degree of use. Five of the fifteen councils indicated a possible future increase, particularly in relation to water rights and allocation, and the development of consent bundling schemes.

Covenants: Like competitions/awards, a low to moderate emphasis for the use of covenants (Figure 2.29) suggests these are minor instruments overall. Seven of the fifteen councils indicated a likely future increase in use, particularly as a mechanism for managing biodiversity on privately owned land. Use was mostly indirect through QE II open space covenants and conservation covenants (Department of Conservation), although Waikato were in the process of developing their own form of covenant.

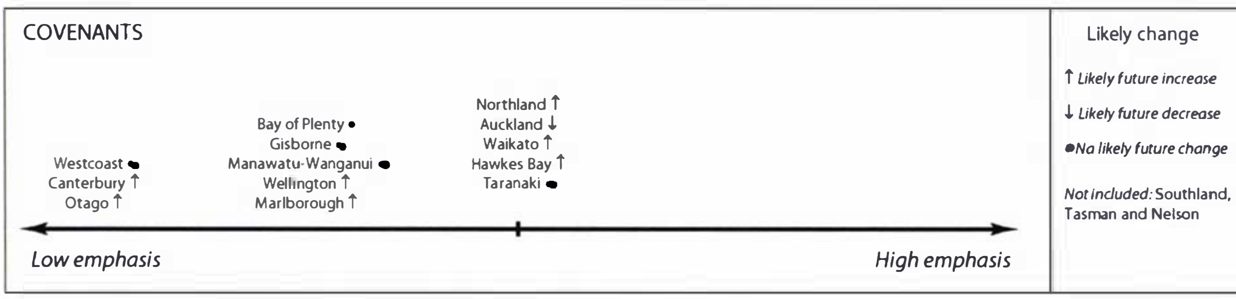


Figure 2.29: Individual council emphasis on present and future use of covenants as a means to promote SLM, relative to other councils.

Management agreements: Nine councils indicated that they make use of management agreements, particularly as they relate to grants/works, long-term pest management, and maintaining tree plantings. For the eleven interviewees who responded, seven thought that their councils' would make greater use of management agreements in the future. The use of 'land improvement agreements' was notable (although having a questionable validity for some areas of SLM), with others ranging from non-binding arrangements through to a wholly binding Memorandum of Encumbrance (Taranaki).

Education: The majority of councils suggested a high emphasis for education, with four of the five lower-emphasis councils indicating a likely future increase (Figure 2.30). This is a key instrument frequently endorsed officially within councils' policy. Waikato suggested the highest emphasis on education. Only four of the fifteen councils distinguished promotional education (*i.e.* strongly linked to advocacy) from education to assist (*e.g.* training, provision of factual information), mostly as public education through mass extension, and environmental education linked with schools. Overall, education is a key instrument with a consolidated use within most councils, with only minor future increases in its use across all councils.

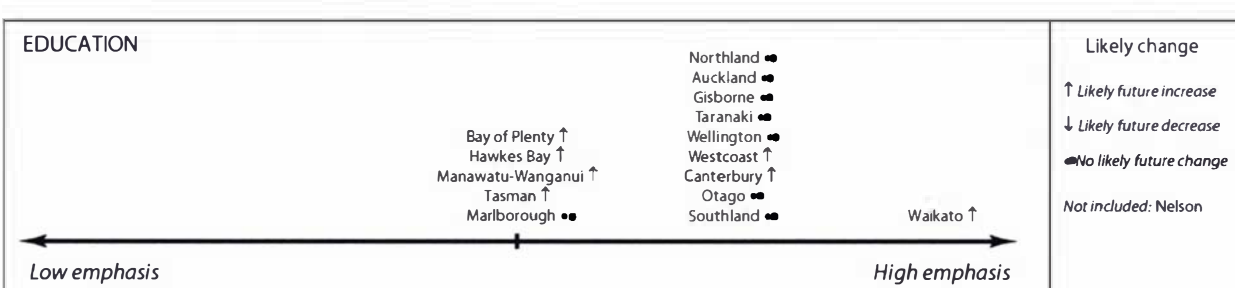


Figure 2.30: Individual council emphasis on present and future use of education as a means to promote SLM, relative to other councils.

2.6.2.2 Extension & delivery instruments

Provision of promotional information: All councils provide some form of promotional information, typically in the form of brochures and flyers. However, most were uncomfortable distinguishing this instrument from the provision of factual information, as brochures/flyers contain factual information, and fact sheets or information packages can be considered to involve a dimension of promotion.

Provision of factual information: The provision of factual information is a major instrument used to promote SLM, and is strongly linked with education and the provision of services. All councils have a range of factual information documents available to farmers, some of which comprehensively cover most (if not all) aspects of SLM. This instrument receives a moderate to high emphasis overall (Figure 2.31), with six of the fifteen councils indicating a likely future increase.

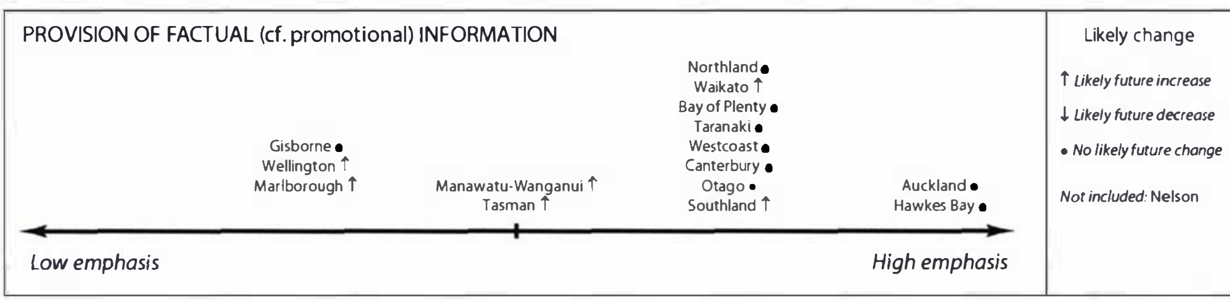


Figure 2.31: Individual council emphasis on present and future provision of factual (cf. promotional) as a means to promote SLM, relative to other councils.

DIY kits: Thirteen of the fifteen councils indicated that DIY kits were used, although this was mostly in a minor way (as kits for farm planning, and for monitoring stream or soil health). Twelve of the fifteen councils indicated a likely future increase in the area of SLM. This suggests a minor use overall (relative to the use of other instruments), but a likely major increase across the majority of councils. The implication being a greater emphasis towards promotion of farmer/community activity and involvement in environmental management.

Farm visits (one-to-one consultation): Eight of the fifteen councils have a decidedly strong emphasis on direct liaison with farmers (on a farm-by-farm basis), and only two councils indicated a likely future change (Figure 2.32). This suggests overall high use of direct liaison nationally, particularly by those councils with strong roots in conventional and traditional approaches to SLM. It also suggests most councils are content with their current emphasis on the use of this instrument.

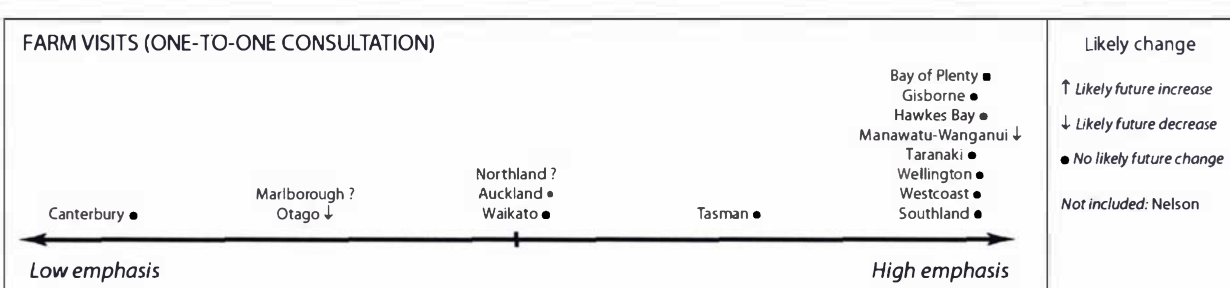


Figure 2.32: Individual council emphasis on present and future use of farm visits (one-to-one consultation) as a means to promote SLM, relative to other councils.

Of the six councils with the least emphasis on direct liaison, only Marlborough and Auckland cited a lack of resources as the reason. The low emphasis of Canterbury, Otago and Waikato was indicated as being a political and philosophical choice. Implicitly and explicitly, this suggests that these three councils (and perhaps others) believe there are more efficacious approaches for engaging farmers in the promotion of SLM.

Field days: All councils make use of field days, ranging from Otago's high emphasis of twenty field days per year, down to the one or two held annually by some of the lower-emphasis councils. Northland, Bay of Plenty and Taranaki integrate with field days run by other agencies, rather than having their own explicit programmes. Only four of the fifteen councils indicated a likely future increase (Figure 2.33). Those who favoured field days considered them to be an efficient means of engaging large numbers of farmers. Those who expressed disfavour considered them to be expensive and time consuming to organise; as having no guarantee of attendance; and the intangible outcomes carry little perceived impact on the promotion of SLM (relative to the level of investment). Overall, use is widespread but variable, with increases in future use likely to be minor.

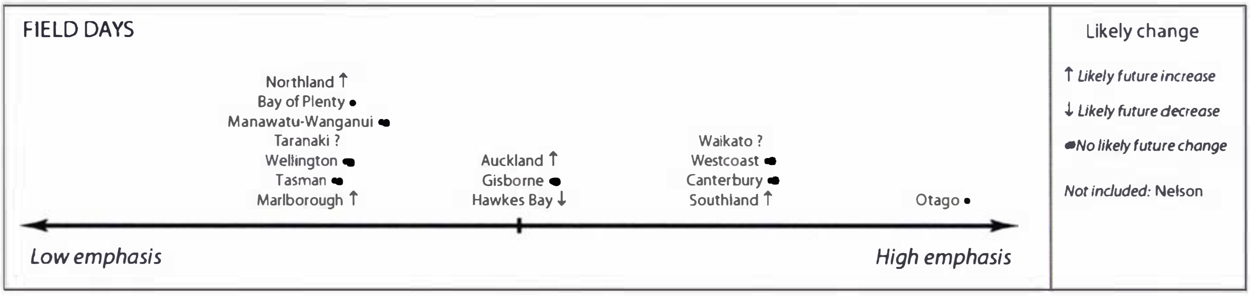


Figure 2.33: Individual council emphasis on present and future use of field days as a means to promote SLM, relative to other councils.

Landcare groups: Most councils used Landcare groups to promote SLM, typically through the provision of funding, administration, and other forms of support. The suggested degree of emphasis ranged widely, and eight of the fifteen councils indicated likely future increases in either support or group numbers (Figure 2.34). Opinions regarding Landcare groups were very strong, with some interviewees debunking them as being politically correct 'feel good' exercises with little meaningful contribution to the promotion of SLM (at least as it relates to agriculture). Surprisingly, it was not necessarily the interviewees from the lower-emphasis councils that expressed these views. Overall, the use of Landcare groups appears to be widespread but variable, and perhaps increasing (particularly in regions where emphasis is already high).

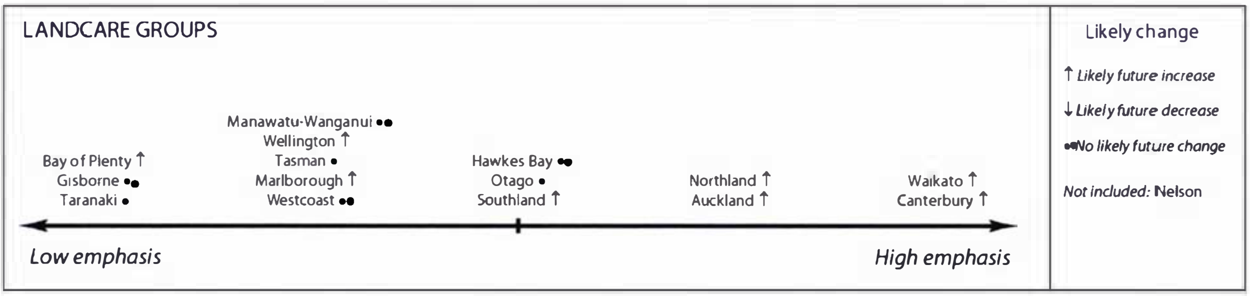


Figure 2.34: Individual council emphasis on present and future use of Landcare groups as a means to promote SLM, relative to other councils.

Focus farms: Councils make little use of this instrument. Very few have their own focus farms, with most preferring to integrate with initiatives run by other agencies (particularly the then MRDC). Of the twelve interviewee responses, only two indicated a likely future increase in the use of this instrument. This suggests a minor use overall (on a national basis), which is unlikely to increase significantly in the future.

Farmer discussion groups: Twelve of the fifteen councils use farmer discussion groups, mostly in a minor way. Eleven of these integrate with industry groups (namely Livestock Improvement Corporation discussion groups) on an invitation basis. Taranaki have their own hill country discussion groups, while Waikato has sheep and beef liaison groups. Seven councils indicated a likely future increase, particularly in regions with a notably growing dairy industry. Two councils stated that discussion groups are an effective means of engaging farmers not usually interested in council promotion of SLM. Overall, the suggestion is a minor use on a national basis, and perhaps a moderate increase.

Other community groups: Council use of this instrument for the promotion of SLM was distorted by some respondents using it as a category to distinguish various non-agricultural type care-groups (dune-care, stream-care, coast-care, etc.) from Landcare groups. Only four councils indicated a use of community groups directly related to agriculture, including Waikato (sheep and beef liaison groups), Manawatu-Wanganui and Hawkes Bay (pest control groups), and Wellington (catchment community schemes).

Regular publications: Fourteen councils indicated a use of regular publications, mostly as generic region-wide newsletters and newspaper articles. Only six councils stated they used a newsletter explicitly targeting SLM and rural rate-payers. Seven councils indicated a likely future increase in use. This suggests a minor use overall, and perhaps a slight overall increase in use.

2.6.2.3 Summary trends and implications

By considering interviewees' responses to their councils' use of regulation (as a standalone instrument) and overall approach to the promotion of SLM, some general inferences can be made regarding the relation between regulatory and non-regulatory approaches (Figure 2.35). The majority of councils appear to favour a non-regulatory emphasis for land/soil management, with only five appearing to skew towards regulation. While all councils may prefer a balanced or non-regulatory emphasis, these five councils are subject to particular influences that currently necessitate a regulation emphasis almost by default.

Firstly, resourcing appears to be a major influence, with all of the five councils having limited staff or funding to invest in the promotion of SLM. This may also relate to the ability to develop a non-regulatory SLM programme, particularly in regard to Marlborough, Nelson and the Westcoast. Secondly, all but the West Coast are unitary authorities, suggesting the historical preference for regulation on a territorial basis may have overflowed into regional responsibilities and management (particularly with Nelson and Marlborough).

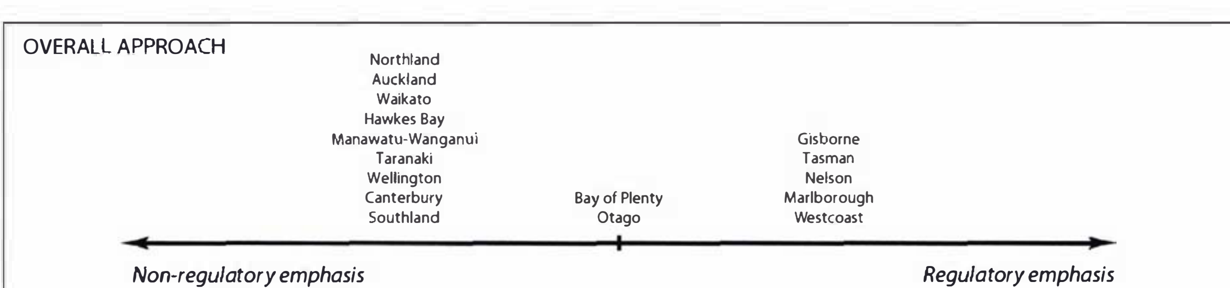


Figure 2.35: Interpretation of regulatory orientation of councils' overall approach to the promotion of SLM.

Thirdly and finally, Gisborne's individual difficulty and magnitude of SLM issues relating to back-country erosion may not be readily amendable to non-regulatory approaches. Previous efforts (and considerable investments) to establish Landcare groups in the Region have been unsuccessful, and despite progress through the East Coast Forestry Project (≈30% of the 60,000 hectares targeted as the Region's worst erosion has been forested), the Council estimates $185 million of investment is still required to promote and effect soil conservation on land outside the Project (Boffa Miskell, 2000). This is well beyond the Council's resourcing.

Another potential long-term trend indicated by four of the councils, was for a conditionally strategic increase in the use of regulation if non-regulatory approaches fail to eventuate as an effective means of adequately promoting SLM. The suggested term of consideration was 10 years (*i.e.* the duration of a regional plan), which aligns well with a central government forewarning stated in the SLMS: 'significant progress must be made towards SLM in the next ten to fifteen years... unless there is clear progress, there are likely to be calls for more direct regulatory or tax-related intervention' (MfE, 1996, p.9).

The government may have a potentially strong argument for greater use of regulation. If every effort has been made to encourage and aid farmers (through 10-15 years of advocacy, education and assistance), and provided that objective measures demonstrate no 'clear progress' (*i.e.* through environmental monitoring), then the government may be forced by public pressure to tighten the regulatory dimension of the RMA. The extreme implication for farmers is clear. Either voluntarily and proactively adopt SLM under the current non-regulatory regime, more or less according to a self-designated schedule and design, or be forced to adopt under a regulatory regime according to a government design and schedule.

CONCLUSIONS

The aim of this study was to identify how regional authorities are attempting to promote and effect the sustainable management of farm-land throughout New Zealand.

- All regional authorities use a combination of instruments to promote and effect their SLM policy. Principal instruments include regulation, education, advocacy and assistance (as grants, advice, information and services).

- The use of grants is widespread across eleven councils. Bay of Plenty, Manawatu-Wanganui, Southland and Wellington Regional Councils appear to afford high emphasis to the use of grants within their respective policy instrument combinations. Nationwide, the use of grants is likely to increase in the future, particularly in regard to the management of on-farm riparian and biodiversity resources.

- All RAs provide services as a means to promote SLM, with the majority placing a high emphasis on the use of this instrument within their overall mix of implementation methods. Most appear to be reasonably content with their current levels of service provision.

- Competitions/awards and covenants are both minor instruments used by most RAs. Trends in future use suggest the majority of RAs are seeking to consolidate the use of these instruments.

- Most RAs use regulation as a backstop to other approaches for promoting SLM. Those that place a higher emphasis on regulation tend to do so by default (because of limited resourcing), although unitary authorities may also do this for political reasons related to their territorial functions.

- Education receives a moderate to high emphasis by all RAs, and most particularly by Waikato. Nationwide, future increases in the use of education are likely for six RAs.

- All RAs provide information as a means to promote SLM, with the majority affording a high emphasis to the provision of factual information. Only minor increases are likely on a national basis.

- DIY kits currently receive minor use relative to other instruments, but a major future increase is likely across most councils.

- The emphasis afforded to the use of farm visits (one-to-one consultation/liaison) varies widely across RAs, although the majority skew towards a decidedly high emphasis. Most RAs appear to be reasonably content with their current degree of use.

- The use of field days and Landcare groups is widespread but variable. Future increases are likely for both instruments (less for field days).

- Differences in funding, tradition, internal politics and philosophies, interpretation of legislative requirements, and the physical nature of regional resources and SLM issues, all appear to have a large bearing on the mix and character of policy instruments used by individual authorities.

- There appears to be a wide philosophical difference between some councils over the use of collective and one-to-one approaches to promoting SLM. Canterbury, Otago and Waikato place significant emphasis on collective approaches (*e.g.* Landcare groups, field days), and a lower emphasis on one-to-one approaches. In contrast, the majority of councils place a decidedly high emphasis on one-to-one farm visits, but a generally lower emphasis on collective approaches.

- The greater majority of RAs have a non-regulatory emphasis characterising their overall approach to the promotion of SLM. Those with a regulatory emphasis have either limited resources, underdeveloped SLM programmes, or in the case of Gisborne, SLM challenges that are not readily addressed through non-regulatory mechanisms. All unitary authorities appear to skew towards regulatory approaches, suggesting their territorial dimension may influence regional management.

- The current overall emphasis on non-regulatory approaches may change in the long term for some councils. If non-regulatory approaches fail to result in significant progress within 10-15 years, then some councils and central government may shift to a greater regulatory emphasis. The implication for farmers is to voluntarily and proactively progress SLM on their own farms, or be forced to do so in the future under greater controls on agricultural land uses and activities.

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Chapter 3

LAND RESOURCE INFORMATION & LAND EVALUATION FOR SUSTAINABLE FARMING

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INTRODUCTION

Many commentators assert a lack of information as being an important reason as to why farmers continue to resist promotional efforts concerning sustainable resource management (*e.g.* Morgan Williams, 1995; Rauniyar & Parker, 1998; Bennet *et al.*, 1999; Bradshaw & Williams, 1998; Rhodes *et al.*, 2000). While the agricultural community is constantly bombarded with new information (leading to a current state of 'information overload'), this does not necessarily mean that farmers are receiving quality information when it is most needed (Rhodes *et al.*, 2000). As will be discussed, quality information for agricultural decision-making is generally regarded to be that which is timely, relevant, reliable, affordable and understandable.

Farm-scale *land resource information* (LR information) is particularly relevant to New Zealand farmers interested in improving farm sustainability. Such information describes the character and condition of natural resources (*e.g.* soils, geology, ecology, hydrology, vegetation, *etc.*) as it varies on a farm-by-farm basis[1], and can be used to interpret land capability (as the ability of land to sustain a given land use overtime). Because socio-economically sustainable land uses must develop within the physical and biophysical capabilities of land (Eyles & Newsome, 1991), LR information can be regarded as a fundamental prerequisite for planning and demonstrating farm sustainability (McKenzie & McDonald, 1994; Basher, 1997).

LR information is not commonly used to any great extent in NZ pastoral agriculture, as farmers in this country tend to have an intimate knowledge of their own farmland (Cessford, 1985). Such knowledge has likely been gained through experience & familiarity, trial & error, transfer by analogy, and other subjective-informal methods of assessing and evaluating land (as described by McKenzie, 1991; Dalal-Clayton & Dent, 2001). While this 'knowledge of the land' has been adequate for farm decision-making in the past, it may no longer be sufficient for meeting the challenges of modern-day agriculture.

The process of obtaining and using LR information in decision-making is often described as *land evaluation*. This is not a particularly well recognised term in NZ pastoral agriculture, perhaps due to the widespread versatility and suitability of pasture as a crop (historically decreasing the need for land evaluation), and an associated lack of land evaluation frameworks designed to accommodate the characteristics of NZ pastoral farming[2]. However, as modern-day farming is continually challenged by increasing sustainability problems and greater system complexity, there is now considerable opportunity for a greater use of LR information and formal land evaluation frameworks in the pastoral agriculture industry.

The aim of this chapter is to review and relate the theory of land evaluation to the planning of sustainable pastoral farming systems in New Zealand. This has been achieved solely through literature research. In doing so, this chapter provides a necessary platform and framework for other studies presented in successive chapters.

[1] The NZ landscape exhibits a marked degree of spatial variability in terms of land resources (Molloy, 1980; Webb & Wilson, 1995; Rhodes *et al.*, 1999; Gillingham & Betteridge, 2001). In many areas, land resource variability is expressed at the sub-field scale, such that most NZ farms can be considered to have a unique combination and distribution of land resources (the exception being farms contained within extensive landforms that exhibit only minor variation across large areas – *e.g.* the Canterbury Plains).

[2] The application of *farm-scale* land evaluations in NZ has generally been limited to intensive land uses (cropping, horticulture, viticulture) and conservation farming (for erosion control). Numerous examples exist for conservation farming, but they tend to focus on environmental management for the public good (as the evaluations have been funded by public monies).

THE IMPORTANCE OF INFORMATION

Information can be defined in a number of different contexts. Biologically, information can represent the stimulating medium through which our sensory faculties interpret the world (*i.e.* via light, sound, odour, etc.), or the internal electrical or chemical stimulations that allow us to function and react (*e.g.* hormones, impulses). Systems theory defines information as a resource that is exchanged or transformed within systems of communication, control, and other forms of cybernetics (Clayton & Radcliffe, 1996). In common terms, information can also be interpreted as the recorded facts and explanations found in texts, pictures, equations, and their digital equivalents. From an epistemic perspective, information is the facts and truths translated to and from knowledge, and communicated between people.

Despite strong and overlapping similarities, information is not knowledge. As noted by Stantiall (2000), knowledge and information are discrete concepts, even though they are commonly used interchangeably as synonyms. Knowledge is an intangible entity that resides in the minds of individuals, communities and societies (*e.g.* local knowledge, traditional knowledge, indigenous knowledge). It is generated internally, either as a deduction from observed facts (*a posteriori* knowledge), or as inductive reasoning that uses self-truths rather than observed facts (*a priori* knowledge). As an example, conventional science often relies on inductive reasoning to explore a theory and generate a hypothesis, and deductive reasoning to test the hypothesis through experiment.

A person's knowledge is unique, and cannot be transplanted into another person's mind (*ibid.*). Rather, knowledge needs to be communicated as information, and interpreted by other individuals according to their own contexts and worldviews (*i.e.* people can interpret the same information differently). Hence, information can be distinguished as an entity that can be shared, transmitted, and communicated. It can also generally be stored in a communicable form (as documents, books, films, digital data[3], etc.) and identically reproduced or duplicated. In a system sense, information is the resource that represents the input and output of a 'system of knowing', while the throughput represents knowledge.

Information has a fundamental importance in the process of decision-making, and its variants of problem solving and planning. Decision-making can be defined as a cyclic process of determining, implementing and monitoring an appropriate course of action, typically in response to a problem, opportunity or event. This can range from making simple short-term decisions such as deciding whether or not the lawn needs mowing this weekend, through to complex long-term decisions that involve multiple objectives and unpredictable outcomes.

Information gathering
Data evaluation
Problem structuring
Hypothesis generation
Hypothesis evaluation
Preference specifications
Action selection
Decision evaluation

Figure 3.1: Steps involved in decision-making (Nickerson & Feehrer, 1975 in Nuthall, 1999)

Many different models have been put forth to explain decision-making, particularly in relation to strategic planning (*e.g.* the plan-implement-control cycle; the plan-decide-act or PDA model). Such models are typically expressed as cycles, whereby key steps (*e.g.* Figure 3.1) feed back upon themselves in response to new external information, or new information generated from the process itself. As an example, if a hypothesis is designed and evaluated but found wanting, then a new hypothesis is erected and evaluated. This could continue through a number of cyclic iterations, until a valid hypothesis (or feasible option/solution) is identified.

[3] Some commentators do not consider data to be information (*e.g.* Wilkinson, 1996). Rather, to be information data must first be interpreted to give it meaning. As will be discussed, forms of data are considered here as *descriptive information*, while information translated according to a given purpose is regarded as *interpretive information*.

Decision-making can be a formal or informal process[4], or a combination of both. Formal processes are usually based on systematic, transparent and reproducible methodologies. Examples include scientific method, decision-support technologies, and conceptual frameworks that seek to organise and clarify the decision-making process. Informal decision-making (also known as subjective-informal or subjective-intuitive decision-making) is characterised as being an unconscious and/or hidden process that takes place within the minds of individuals. It is likely to be a tacit process (a decision may be reached but the process cannot be explained), and one that cannot readily be scrutinised by peers. As such, informally derived decisions can be difficult to defend or justify, and they can carry a high risk of being biased or flawed.

Decision-making cannot function effectively without appropriate information (Gibbs, 1982; Wright, 1988; Webby & Sheath, 1991). As a resource, inappropriate or insufficient information will impair the function and performance of a cybernetic system, just as limited physical resources will impair the production of biophysical systems. However, we have a finite ability to process information, and we can never have complete information (*e.g.* we cannot know the future). Hence, we are usually required to make decisions in the absence of complete information, which imbues many (if not all) decisions with an element of risk and uncertainty. A sound decision seeks to account for this risk as far as practicable, by making best use of existing information and understanding to predict and account for potential outcomes (*e.g.* scenario modelling and analysis, contingency planning, risk aversion, the precautionary approach).

3.1. INFORMATION, DECISION-MAKING & FARM SUSTAINABILITY

A number of New Zealand farmer-focused studies have identified information as a constraint to successful and/or sustainable farm management. Morris *et al.* (1995) interviewed 61 Canterbury farmers to investigate the relation between technology transfer and farmer adoption of new technologies. A key finding was that farmers were receiving too much information. Although this was not necessarily overwhelming, the task of sifting through information to identify that which was relevant and appropriate to the farm was difficult and time consuming. Also, multiple sources of information were often identified by farmers as being contradictory or conflicting.

Butcher & Thomas (1997) undertook a similar study through survey, aimed at identifying farmers' most important sources of technological information (as discussed in Butcher, 1998). They identified three main information constraints: information is not always in an appropriate form; the cost of some information is too high; and farmers are concerned about the reliability and objectivity of information (thereby preferring to source information from an independent or trusted source).

Bradshaw & Williams (1998) interviewed 32 agricultural professionals (including 25 farmers) to gain an understanding of information and communication needs as they relate to sustainable land management in North Island hill country. Most of the farmers stated a 'need for more site-specific information about their particular farm resource' (p.15), and a tendency to access information only when they need it or decide to take action.

Rauniyar & Parker (1998) sought to identify constraints affecting the adoption of sustainable management through a workshop forum (30 agricultural professionals), and a national mail survey (316 respondents). Information was identified as a constraint, particularly in relation to farmers being able to access reliable information.

[4] The four-way relation between inductive/deductive knowledge and formal/informal decision-making is vague. Formal decision-making can be inductive (*e.g.* generating potential solutions, options, ideas, hypotheses, etc.) and deductive (*e.g.* testing the validity or feasibility of potential solutions, options, etc.). Likewise, informal decision-making can also be both inductive (*e.g.* intuition, innovation) and deductive (*i.e.* makes use of scientific facts and observation). However, in being a wholly mental activity, informal decision-making tends to lean more towards inductive methods of gaining knowledge, while formal decision-making is more commonly associated with deductive methods.

Mulcock & Ensor (1998) undertook workshop studies to review best practices for sustainable land management in South Island high country. They described a 'barrier' between information providers and the use of information in farm decision-making. To pass through this barrier, information must be relevant, timely, trusted, and understandable, and the farmer must have the skills, knowledge and ability to obtain and use new information. Farmers receiving an overwhelming amount of information ('information overload') was also noted as a constraint.

Rhodes *et al.* (2000) undertook a range of farmer-focused studies to identify factors constraining North Island hill country farmers from achieving optimal economic and environmental performance. They identified several information related constraints, including information overload, information gaps (the information does not exist), and the ability of farmers to 'ask the right questions' towards sustainable management and the procurement of appropriate information. Farmers also emphasised a need for reliable information in an appropriate form.

Many other commentators also recognise that ideal information for decision-making needs to be timely, reliable, relevant (*e.g.* site-specific), affordable, presented in an understandable and appropriate form, and complementary to existing information/knowledge (Moore, 1990; Ching, 1991; Sheerin, 1991; Rhodes & Aspin, 1993; Cartwright, 1994; Graham, 1994; Parminter, 1994; Wilkinson & Parminter, 1997; Bennet *et al.*, 1999; Dalal-Clayton & Dent, 2001). Likewise, many argue, state, or suggest that the ability of farmers to use information and make effective management decisions will determine whether or not a farm is successful and sustainable (Wyllie, 1953; Gibbs, 1982; Webby & Sheath, 1991; MAF, 1995; Morgan Williams, 1995; Butcher, 1998; Morriss, 1998; Zilberman & Lipper, 1998; Pyke & Johnstone, 2000).

These considerations can be refined into a statement to explain the relation between information, decision-making and sustainable management. That is, *farm sustainability is determined by the ability of management to make sound decisions, which in-turn is strongly dependent on the quality of information used in the decision-making process.* At face value, this statement may seem to ignore external influences beyond management's control (*e.g.* market fluctuations, climate, disaster, social pressure and related legislation). However, it is these very influences that necessitate the activity of management, at least from an environmental perspective. This is because management must accommodate changes and deviations caused by externalities, if the farm is to have any hope of achieving it's objectives. Put another way, a farmer must constantly adjust the farm system in a way that both capitalises on opportunities that arise through change, and avoids, counteracts or mitigates any threats that arise. Further, a farmer may seek to build-in some resilience against change, to promote stability and lessen the need for constant refinements.

3.1.1 THE DEFINING INFLUENCE OF MANAGEMENT

The defining influence of management is well recognised. Wyllie (1953) asserted 'whatever the conditions of the soil, climate, topographical layout, and so on may be, it is the farmer and his [or her] workers who determine whether the farming will be good, bad, or merely indifferent' (p.4). Similarly, Parminter (1994) states that land users cannot farm the land sustainably 'if they lack the information and/or skills to do so' (p.427), while MAF (1995) claims that research has distinguished "the farm manager's decision-making ability" as the reason why farm performance differs between farms operating in similar environments (p.1). Indeed, as discussed in Chapter 1 (Section 1.7), management represents the overarching cybernetic system that coordinates and regulates sub-systems (in response to internal deviations and external change), and in doing so, it defines the function and performance of the greater system.

Modern farming is a complex and sophisticated undertaking (Kelly *et al.*, 2000). Farmers are required to simultaneously manage numerous farm-internal systems (Chapter 1), many of which are dynamically complex, unpredictable, and continue to function outside the understanding of science (particularly biological systems). Further, in being part of greater social, economic and biophysical systems, farming is particularly exposed to external perturbations, such as weather, biosecurity threats, market fluctuations, and so on. Indeed, the unpredictable and uncontrollable nature of many such factors can be considered as a key feature distinguishing the business of farming from non-agricultural endeavours.

Farming is set to become even more complicated and challenging in the future (MAF, 1995; Butcher, 1998; Roberts, 2000). Agricultural related advances in science and technology continue to accelerate, particularly in the areas of biotechnology, communication, and information systems. In a social sense, society appears to be having a greater influence on how farms operate, particularly in relation to animal health & welfare; public access to private land; the impact of agriculture on resources and environment; and increased restrictions being imposed through legislation. Economically, consumer preferences are constantly changing; demand for commodities is generally accepted to be decreasing relative to increasing production costs and land prices; and international markets continue to distort global trade through subsidies and export barriers.

While farmers are certainly the ones who are best placed to manage this complexity, some commentators suggest that farmers' ability to manage their farms in a sustainable manner is not keeping pace with change. Indeed, some actually consider unsustainable land-use and practice to be an outright expression of poor or inadequate management (*e.g.* Molloy, 1980; Zilberman & Lipper, 1998).

3.1.2 FORMAL AND INFORMAL DECISION-MAKING

New Zealand farmers have traditionally used a combination of formal and informal approaches in management and decision-making (Parker *et al.*, 1993; Wilkinson, 1996; Parker *et al.*, 1997; Mulcock & Ensor, 1998). However, relative to non-agricultural enterprises, farmers in general have been noted to emphasize informal management approaches over the formal:

> *'A few years ago Malcolm (1990) looked back over fifty years of farm management research and practice in Australia. What he concluded applied equally to most countries. He noted that despite all the research and development on a wide range of decision models and systems, the farmers of today still largely rely on intuition, experience, and simple budgeting'*
>
> Nuthall, 1999, p.1.

Parker *et al.* (1993) state that many farmer-focused surveys in New Zealand suggest that the majority of farmers use a subjective-informal approach to management. This is reiterated by Parker *et al.* (1997), who also describe informal management as being 'largely based on experience, intuition and visual observation' (p.192). Parker (1999) later claims that most farmers are 'informal strategists' - while they can broadly state their farm objectives, the mechanisms that they use to achieve these objectives are generally 'woolly' (p.39).

Wilkinson (1996) interviewed 115 Hawkes Bay farmers and found that they preferred to use informal approaches for monitoring stock performance and resource condition. Going around the farm and making informal (and usually observational) assessments was considered to be what a good farmer does automatically. To a lesser extent, farmers used formal monitoring to provide supplementary information to help solve specific problems.

Similarly, Mulcock & Ensor (1998) draw heavily on Wilkinson & Parminter (1997) to explain farmers' preference for informal monitoring. Informal monitoring is generally undertaken through visual assessments, resulting in information "that is never written down but is stored in the farmer's head" (p.2). Further, few farmers are able to explain the process of informal monitoring without considerable prompting from someone else. Rather, informal monitoring was simply considered to be 'part of the skill of being a good farmer' (*ibid.*). Formal monitoring was more likely to be undertaken for making once-off production decisions.

Moore (1990) links farmers' informal management approaches to a preference for experiential learning. Relative to their urban counterparts, farmers and rural children are generally reluctant to undertake formal education and training (due in part to an historically-limited agricultural curriculum in schools). Rather, 'popular opinion proclaimed that you did not learn farming from a professor and books, you learnt it from farming' (p.30). This was supported by Emery and Oeser (1958), in stating that farming knowledge is something that 'must be achieved and tested by personal practice and experience, and it is handed on from father to son, and between contemporaries, by means of traditional rules and face-to-face communication' (p.30).

Key features of farmers' informal decision-making appear to be an inexplicit or unconscious process, and a reliance on observation and experience to monitor or assess farm character, condition and performance. In being a personal and unconscious activity, this means the knowledge generated from these processes is likely to be tacit.

3.1.3 ADVANTAGES AND DISADVANTAGES OF INFORMAL DECISION-MAKING

Tacit knowledge is simply that which we know but cannot put into words (Polanyi, 1966). Mascitelli (2000) describes it as the vast sea of knowledge that 'lies below the surface of conscious thought and is accumulated through a lifetime of experience, experimentation, perception and learning by doing' (p.182). While we can know a fact or truth from tacit knowledge, we may be unable to explain to other people why we know that fact; we may be unable to explicitly state the rationale behind decisions made using tacit knowledge; and skills 'learned by doing' are a reflection of tacit knowledge (Hudson, 1992).

Tacit knowledge and related processes carry two major advantages for farm management decision-making. Firstly, they allow rapid consideration of complex problems in an holistic-like manner (we can generate, consider, and evaluate many different ideas, options, potential solutions or hypotheses, seemingly in a simultaneous way). Considering the dynamic complexity of farming, this is a particularly important feature for successful farm management. Secondly, tacit knowledge and processes are considered to be responsible for innovation, creativity, imagination, resourcefulness, and intuition. Applied to farming, many of these factors are sometimes expressed together as the 'No.8 wire' approach. With the challenges now facing agriculture, farmers' ability to be innovative is an important resource for sustainable farming.

The downside to tacit processes is a lack of objectivity and transparency. As mentioned previously, this means that tacitly derived decisions can be difficult to defend or justify, and they can carry a high risk of being biased or out-rightly flawed. Additionally, being unable to express how a decision is reached is likely to impair communication between farmers and those seeking to help farmers make better decisions (consultants, advisors, council officers, etc.). Furthermore, it can be difficult to review a bad decision to identify where the process went wrong. Together, these factors represent a major disadvantage and impediment to decision-making in sustainable management.

It is for these and other reasons that many commentators recommend farmers adopt more formal approaches to management. Most are in general agreement that traditional approaches to farm management need to become smarter, more formal and strategic, more knowledge-intensive and information rich, and more environmentally orientated (Morgan Williams, 1995; Wilkinson, 1996; Parker *et al.*, 1997; Mulcock & Ensor, 1998; Parker, 1999; Luxton, 2000; Taylor, 2000). However, this is not to say that farmers should suddenly overturn or discard their traditional approaches to management. Some of the advantages of informal decision-making have been discussed, and it is perhaps unrealistic to expect that farmers should adopt overly formal management systems (Davidson & Martin, 1968; Wilkinson, 1996).

One special area of farm management that could be improved concerns land. Although representing the greatest single investment of a pastoral farming business (Rhodes et al., 1999), the land resource of most New Zealand farms has rarely been formally assessed and evaluated at a scale suitable for farm decision-making. There are exceptions (namely soil conservation surveys), but it can be argued that the information they contain is not in an appropriate form, and even if it was, farmers have no sure place for such information in their decision-making process. The only other consistent exception is information gained through regular soil testing, but this is far from being a universal farm management activity.

In the absence of formally-derived land resource information, New Zealand's pastoral farmers must try to achieve farm sustainability (and demonstrate sustainable land management) almost solely through the use of information and knowledge gained through informal processes.

LAND AND LAND-RESOURCE INFORMATION

3.2. LAND AND ITS RESOURCES

Land is a fundamental concept that can be interpreted in many different ways (Davidson, 1980). In common terms, land may be interpreted simply as a terrestrial surface distinct from water and air (we may travel across the land), or as an holistic 3-dimensional space in which we live and exist (we may travel through the land). Within socio-economic systems, land may be reduced into cadastral parcels to become a tradable good (property), a factor of production (a production resource), or an enterprise component (capital). Land sciences and related disciplines concerned with the interface between land and its management (*e.g.* soil science, precision agriculture, land evaluation, agricultural science, nature conservation, natural resource management) tend to define land as a construct that can be reduced to its composite biophysical components (*e.g.* Cuff *et al.*, 1988; Gunn, 1988; Davidson, 1992; Dent & Young, 1981; van Diepen *et al.*, 1991; FAO, 1997; Dalal-Clayton & Dent, 2001). This is captured in one of the most cited definitions for land, whereby the phrase 'attributes of the biosphere' is used to describe and group these composite components:

> *'Land: an area of the earth's surface, the characteristics of which embrace all reasonably stable, or predictably cyclic, attributes of the biosphere vertically above and below this area including those of the atmosphere, the soil and underlying geology, the hydrology, the plant and animal populations, and the results of past and present human activity, to the extent that these attributes exert a significant influence on present and future uses of the land by man'*
>
> FAO, 1976, p.67.

Many other terms and phrases are used to describe land components, including *natural resource features* (Stewart, 1968), *aspects of land* (McKenzie, 1991), *biophysical resources* (Webb & Wilson, 1995), *land use resources* (Sys *et al.*, 1991), *physical environmental characteristics* (Davidson, 1992), *natural resources* (van Lanen *et al.*, 1992; Dalal-Clayton *et al.*, 2003), and many other assorted variations. In New Zealand, the term *land resources* is commonly used (*e.g.* MoW, 1979; Molloy, 1980; Hunter, 1986).

Land resources are generally taken to include soils, vegetation, and hydrology, along with the more indirect resources of lithology, landform, climate, and perhaps even fauna and biodiversity (particularly in an ecological or natural sense). They are characterised as resources that can directly influence ***or*** be influenced by, land use and management (in most cases). This attributes them as surface or near-surface resources (both above and below the surface), and natural resources that can be modified through a significant investment of work or energy (vegetation clearance, drainage, land improvement, etc). It is not usual to include man-made resources (*e.g.* fences, roads, utilities, structures), as these tend to be grouped separately as infrastructure, or together with land at higher hierarchies (*e.g.* within *farm resources*, or in the case of the Resource Management Act, within *natural and physical resources*).

While all these resources interrelate to define land, there is perhaps a tendency to firstly think of the soil resource when discussing land resources. Indeed, soil is often implicitly or explicitly included in most, if not all, definitions of land (can there be land without soil?), and most land resource surveys and evaluations have included soils almost by default, either as a standalone resource (*e.g.* soil survey & interpretation) or as a component within land inventories.

This focus can be attributed to at least two main factors. Firstly, soil is the singular resource that best represents land. This is due to five soil-forming factors of climate, parent material, organisms, and surface relief, all interacting together over-time to produce the soil mantle (Jenny, 1941). These are essentially land resources, although they are often expressed differently in contemporary terms. Hence, because soil results from the interaction of many land resources, it can be considered as the most representative resource that best describes land for general purposes[5].

Secondly, soil is the medium of terrestrial plant production, and therefore represents the underpinning foundation of land-based agriculture. The importance of agriculture to human survival and societal development cannot be overstated, and modifying and managing soils has long been recognised as a means of increasing agricultural production. For this reason, extraordinary efforts have been made around the world to survey soils for agricultural development. In industrialised nations, much of this survey work was undertaken during the 1950-60s (the 'golden age of soil survey'), when agriculture was strongly supported as an important contributor to the growth of economies and the well-being of nations. Likewise, agricultural development in less industrialised countries has frequently been targeted by international aid agencies as a means to alleviate poverty. Many of these development projects during the 1970s and 1980s were underpinned by soil and land surveys (the 'golden age of land evaluation').

3.3. LAND SUSTAINABILITY & LAND CAPABILITY

The importance of land can be described in terms of its functions (Figure 3.2). More simply, land has a functioning capacity to regulate natural processes, support and nourish life, and to physically support structures, systems and activities. This capacity of land to support, nourish and regulate is often expressed partly as ideas of land capability and its variants, many of which are amendable to a systems interpretation of sustainability. In Chapter 1, sustainability was expressed as *the ability of one or many systems to sustain one or many systems over time*. Applied to land, this can translate to *the ability of land to sustain one or many purposes, uses, or systems of use, over-time*. This is almost the same as most definitions of land capability (Figure 3.3, overleaf), although it does not distinguish between actual and potential use (potential use tends to be of interest when land is assessed to improve performance through land use change).

THE MANY FUNCTIONS OF LAND

- Production function
- Biotic environmental function (incl. biodiversity)
- Climate-regulative function
- Hydrologic function (regulating water flows and quality)
- Storage function (*e.g.* mineral resources)
- Waste & pollution control function (incl. filtering, buffering, and transforming pollutants)
- Living space function
- Archive or heritage function
- Connective space function (as a medium of transfer)

Figure 3.2: The many functions of land (adapted from FAO, 1997).

[5] This does not imply that soil survey is best method for obtaining LR information. The most appropriate method for obtaining LR information is determined by the purpose of a survey, and the appropriateness of a survey method for fulfilling that purpose in the most effective and economical way. Hence, the author considers the historical argument between soil survey and land resource inventory survey in NZ and overseas to be redundant. Neither is better than the other because they are used for different purposes.

Another minor distinction between the two depends on how the term 'use' is interpreted. With land capability, 'use' is often cast in a utilitarian context, such as agricultural land use, urban land use, and so on. However, land can be used for non-utilitarian purposes (*e.g.* nature conservation, heritage protection, aesthetics, recreation), and many organisms make use of the land irrespective of human involvement. Hence, within land sustainability, the term 'use' should be recognised as being applicable to all conceivable forms of land use.

DEFINITIONS OF LAND CAPABILITY

- The ability of land to sustain one or many purposes, uses, or systems of use
- The capability of land to support broadly defined categories of use (Dayal-Clayton et al., 2003)
- The productivity and versatility of the land for all potential land uses (productive and intrinsic) after taking account of all limitations to use (Cuff et al., 1988)
- Capability is the potential of the land for use in specified ways, or with specified management practices (Dent & Young, 1981)
- The suitability of land for productive use after taking into account physical limitations (MoW, 1969)
- The broad overall suitability of soil (land) for use (Cutler, 1977)
- The suitability of land for a specified purpose (Hockensmith & Steele, 1943)

Figure 3.3: A range of land capability definitions.

Land sustainability doesn't exactly 'role off the tongue', and the author has yet to see the explicit use of the concept in literature. Likewise, it can be confusing to discuss more than two types of sustainability relations together (see below). For these reasons, some of the following discussion uses the more recognised idea of land capability in place of land sustainability, despite its utilitarian connotations.

It is also important to recognise that land sustainability and Sustainable Land Management (SLM) are two distinctly separate concepts. While the latter is sometimes used in a confusing way to embody both, SLM represents the active intervention of management to maintain or enhance land sustainability (as the ability of management to sustain… the sustainability of land). While this is confusing in its own right, it does serve to highlight the importance of managerial ability in considerations of sustainable management. This ability is regarded here as a function of skills, knowledge, commitment and resources (*e.g.* finances, labour, inputs), which is similar to impediments to 'land use change' described by Campbell (1992) and Dalal-Clayton & Dent (2001). If one of these factors is absent or lacking, then it is difficult to see how management can successfully sustain land capability other than by accident.

3.4. LAND RESOURCE INFORMATION

Facts, observations and interpretations concerning land resources are formally recorded as *land resource information* (LR information). This is different from *land information*, which is usually reserved for describing cadastral, legal title, and other various types of property information. Most of the following discussion relates directly to the types of LR information used in soil survey, land inventories and land evaluation, although in many cases it is also applicable to topographical information, hydrological information, and information concerning geolog , vegetation and other land resources. Examples of various types of LR information are included in Chapter 4.

LR information can be categorised in a number of ways. McKenzie (1991) distinguishes *point-source information* as that which is observed or measured from specific locations within the landscape (*e.g.* from soil profiles, soil samples, instrument measures), and *area information* derived from either field mapping and interpretation, or the interpolation of point-source data across landscape areas. Taken together, point-source and area information are sometimes referred to as spatial or geo-spatial information, particularly when used in computer-assisted analysis.

3.4.1 DESCRIPTIVE AND INTERPRETIVE INFORMATION

Descriptive information seeks to describe the distribution and attributes of land resources as qualitative and quantitative facts or data. Qualitative facts, observed facts, or 'facts about the land' refer to information that has been derived through empirical scientific procedures. Examples include the field determination of soil morphological & physical attributes (*e.g.* structure, texture, drainage, soil colour), and the activity of mapping landscape units according to predefined methods and criteria (*e.g.* soil survey method). Conversely, quantitative data are obtained through objective measurements either in the field using instruments; in the laboratory using samples; or via remote sensing equipment.

The scientific nature and discipline-particular terminology of descriptive LR information has long been recognised as an impediment to its use by those without a background in land sciences or disciplines (*e.g.* Norton, 1939; Klingebiel & Montgomery, 1961; Gibbs 1959, 1966, 1968; Cutler, 1977). Put another way, the basic data and facts are rarely in a form that is readily understood by those who make regular decisions concerning land or land use (Dent *et al.*, 1994; Latham, 1994; Molloy, 1980; Dalal-Clayton & Dent, 2001; Dalal-Clayton *et al.*, 2003). To bridge this gap, LR facts and data are 'interpreted' or evaluated against the requirements of various land use purposes and socio-economic considerations, to produce *interpretive information.*

Processes for deriving interpretive information will be discussed later as land evaluation. The information itself usually represents various ratings, indexes and classifications of land ***or*** land use potentials, often expressed in terms of capability, suitability, versatility, productivity, vulnerability, or susceptibility. *Land capability* has been defined here as land sustainability for any conceivable use, but it is usually expressed in terms of general or broad land uses (see Figure 3.3), such as pastoralism, forestry, conservation, arable and horticulture. *Land suitability* refers to a specific use or purpose (*e.g.* the suitability of land for a specific crop), while *land versatility* is used to describe many specific uses as distinct from general uses (*e.g.* within arable land use this may include the versatility of land to support many different types of crop, each with its own specific requirements). Productivity is an estimate of potential yields (sometimes indirectly expressed as site indexes or carrying capacities), while vulnerability and susceptibility represent risk potentials for environmental degradation.

The meaning of these terms is sometimes contentious and confusing (van de Graaff, 1988), particularly with the often interchangeable use of capability, suitability and versatility. Further, some of these terms can be used to describe both *land potentials* and *land use potentials*, which can create its own degree of confusion. As an example, a district development project looking for areas of land best suited for growing a specific crop is concerned with *land suitability*, which is different from a farmer with a fixed area of land interested in identifying the most suitable crop for his/her specific area of land (*crop suitability*). The same idea applies to *crop versatility* for many types of land, and *land versatility* for many types of crops.

The difference between descriptive and interpretive information can sometimes be vague, particularly when observational or predictive methods are used to collect facts about the land. This is evident with the interpretation of aerial photos and other remotely sensed data (thereby necessitating ground-truthing), and the estimation of resource attributes based on known relations (*e.g.* the estimation of soil water-holding capacity from measured soil data). The prediction of landscape variables through interpolating site-specific information is perhaps similar. Mapping soil or inventory units is also well recognised as a form of interpretation, whereby the surveyor will delineate units according to his or her conceptual interpretation or model of the landscape (Dent & Young, 1981). Taxonomic soil classifications can also be regarded as a form of interpretation, in that designating criteria are usually taken from specific sites (soil profiles), on the assumption that a given profile is adequately representative of not only the immediate surrounding soil, but also similar occurrences of that soil across the wider landscape (as identified and grouped by the soil surveyor).

Descriptive and interpretative information can be differentiated by the degree of scientific rigour used in their collection (to be discussed). It can also be separated according to temporal relevance. Descriptive information tends to have an extended relevance because most land resources will only change slowly over human timeframes (unless modified by significant investment of work or energy). As a general rule, land resources are considered to be long-term or permanent features of the landscape. In contrast, interpretative information is ephemeral (USDA, 1952; Molloy, 1980; van Diepen *et al.*, 1991), in that it has short temporal relevance. This is because interpretive information is the result of combining descriptive LR information with more dynamic information concerning land use, available technology, and other socio-economic considerations. These considerations change rapidly within human timeframes. Hence, many interpretations can be made over-time from one source of descriptive information, but a single example of interpretative information is only relevant for the duration and purpose for which it was produced.

3.4.2 INFORMATION ORDERED BY ATTRIBUTE CATEGORIES

Another way of categorising LR information is to order it into attribute categories. A land resource *attribute* is a 'neutral, over-arching term for a single or compound aspect of the land' (FAO, 1997, p.12) that exhibits variation across the landscape. It is a term that is generally used when no distinction is made between a land characteristic, property or quality (van de Graff, 1988).

A *land characteristic* is a single-factor attribute that can be directly measured or estimated to produce data (*e.g.* soil colour, electrical conductivity, particle density, soluble P). Individually, a measured characteristic describes the state or condition of that characteristic, and tends to have little immediate practical meaning towards land use. *Land properties* are similar, but they usually represent a composite of two or more characteristics (*e.g.* a measurement of soil strength), and they tend to have a greater practical meaning towards land use. Depending on context, characteristics and properties may also be described as variables, indicators, parameters, thresholds, features, factors, traits or data (after van Diepen *et al.*, 1991).

Land qualities are a little more difficult to define. They represent complex attributes of land that have a high practical meaning towards land use. Sys *et al.* (1991) consider land qualities to be the practical consequences of land characteristics, and state that they may be measured, calculated or estimated. In this way some land qualities are actually interpretations. Further, certain land characteristics can also exist as land qualities (*e.g.* salinity). These are just some of the difficulties associated with the concept of land qualities (see van Diepen *et al.*, 1991 for a detailed discussion).

The FAO defines a land quality as a complex attribute of land which acts in a manner distinct from the actions of other land qualities in its influence on the suitability of land for a specified kind of use (FAO, 1983, 1997). Examples of land qualities demonstrate their interpretative nature and high relevance to land use. A select range includes: trafficability; effluent absorption capacity; the availability of moisture, nutrients, or oxygen for plant growth; root penetrability; soil workability; erosion hazard; and even the 'ability for layout of farm plan' to express the trade-off relation between natural land resource units (*e.g.* soils) and land-use units such as paddocks (after Sys *et al.*, 1991; FAO, 1997; Webb & Wilson, 1995).

3.4.3 INFORMATION ORDERED BY DETAIL

LR information is needed at different hierarchies of decision-making and planning (Bouma, 1997; McKenzie, 1991; Dent *et al.*, 1994; Latham, 1994; Dalal-Clayton & Dent, 2001). The LR information required by a clay mineralogist will be different from that required by a government for national planning. Categories of informational detail concerning land resources are commonly expressed in three ways.

Firstly, LR information can be graded according to the level of measurement or description detail. This is simply an acknowledgement that the same informational topic can be recorded at different levels of generalisation. As an example, McKenzie (1991) draws on other sources to present four levels of detail involved in soil description (Table 3.1). As the level of detail increases, the soil information describes a greater number of soil variables, and according to this particular example, it becomes more scientifically robust.

Level of scientific detail	No. of variables	Type of soil data	Scientific nature	Examples
Low	1	Soil name	Broad, qualitative, static & empirical	Recent alluvial soil
Moderately low	50-200	Profile description	May be detailed but qualitative, static & semi-empirical	Fluvial Recent Soil; greyish-brown sandy loam (2.5Y 5/2)..
Moderately high	80-400	Profile description & laboratory data	Detailed, quantitative and static, but systematic	As above but with routine chemistry & physical data (*e.g.* CEC, pH, etc.)
High	100-500	Direct measures of parameters controlling soil processes	Detailed, quantitative, dynamic & systematic	As above but with data on fluxes and/or temporal changes (nutrient movement, conductivity, flows, etc).

Table 3.1: Four levels of soil description detail used in land evaluation (adapted from McKenzie, 1991; Hackett, 1988; Bouma, 1989).

Secondly, LR information can be ordered into different hierarchies according to predefined criteria and categories. Soil and botanical classifications usually have their own various taxonomies, while geological science has traditionally used classifications based on geological age (age, epoch, era, period, etc.) and lithological classes. This type of information is distinguishable in that it can be portrayed as aggregate hierarchies (*i.e.* many classes aggregate into few), which is different from linear hierarchies based on ordinal scales (see below).

Thirdly, the level of detail provided by spatial (or areal) LR information can be expressed along ordinal scales or resolutions. This is akin to the analogy of a magnifying glass, whereby a low magnification (*e.g.* a magnification of '2') provides a broad degree of information for a large area of surface, while a high magnification (*e.g.* a magnification of '10') provides detailed information about a relatively small area of surface.

Detail in digital imagery is commonly expressed in terms of resolutions (*e.g.* dots per inch, pixels per inch), whereby a high resolution contains more detail than a low resolution image. For aerial photography, maps and vector graphics, it is more common to use a ratio scale. Because of the nature of ratios, a small scale is represented by a large number (*e.g.* 1:1,000,000), and a large scale by a small number (*e.g.* 1:10,000). Hence, a large-scale map provides detailed information for a small area, while a small-scale map provides generalised information for a large area.

3.4.4 INFORMATION ORDERED BY SCIENTIFIC RIGOUR

The conventional method of ordering scientific information is to categorise it according to levels of objectivity. At one extreme, wholly objective information is collected and/or analysed according to structured, reproducible and proven scientific methodologies. Such information has a high degree of scientific rigour; it is theoretically undistorted by human emotion or personal bias; and it is generally quantitative in character. At the other extreme, wholly subjective information is derived intuitively according to personal beliefs and perceptions (and therefore exists firstly as knowledge), and without the order, transparency and repeatability of scientific method. Somewhere between these extremes is information derived through empirical science. Such information tends to be qualitative in character, in that it is usually obtained through observation (*cf.* ordinal measurement) according to scientifically structured (or semi-structured) and tested methodologies.

Explicit categories of LR information based on scientific rigour are difficult to construct. In many cases such information has been derived through a combination of methods, scientific or otherwise. As an example, while a conventional soil survey may be undertaken according to empirical method (*e.g.* soil survey method), the quality of the survey will be strongly dependent on the surveyor's intuition and experience, particularly as it relates to the conceptual development of a soil-landscape model (Hudson, 1992). Likewise, such a survey may be complemented by objective measures of certain soil characteristics (*e.g.* laboratory analysis of samples), and may seek to order soils into a classification based on either qualitative criteria (*e.g.* the NZ Genetic Soil Classification) or a combination of quantitative and qualitative criteria (*e.g.* the NZ Soil Classification). Because of this difficulty, only three very generalised and overlapping categories are suggested here.

Firstly, *local LR knowledge* can be regarded as having a low degree of scientific rigour. This type of knowledge can be defined by adapting WinklerPrins's (1999) definition for *local soil knowledge*. Local LR knowledge is the understanding of local land resources possessed by people living in a particular environment for some period of time. This is similar to ideas of *indigenous knowledge*, but without the cultural distinction. Local LR knowledge is built up over-time, usually through a combination of observation, familiarity, experience, trial and error, and local transfer by analogy or example (to be discussed). Accordingly, it is more likely to orientate towards knowledge about land behaviour as it responds to management (*e.g.* land qualities), although this may occasionally be supplemented by inclusions of more formal LR information.

Secondly, LR information with a moderate degree of scientific rigour includes expert knowledge and information gained through (mostly) empirical and semi-empirical methods. At the greater extreme, this category may also include combinations of both qualitative and quantitative information. Examples include conventional maps, resource descriptions, and classifications ordered by nominal hierarchies. Expert knowledge differs from local knowledge, in that it is disciplined according to learned scientific method and *a posteriori* facts, in combination with experience gained by applying those methods inductively and deductively. It also tends to be specialised rather than generalised.

Thirdly, a high degree of scientific rigour applies to information collected and analysed by minimising interference caused by human perceptions, beliefs and preconceived conclusions or notions (bias). This is increasingly achieved by sophisticated mechanical measurement (*e.g.* instruments used in remote sensing and precision agriculture) and computer processing (*e.g.* dynamics modelling, statistical modelling, system modelling). Such information tends to involve considerable data and data-processing, and is therefore usually expensive and technical.

3.4.5 INFORMATION ORDERED BY UTILITY

Information is of little practical worth until it is used. Utility is a measure of practical worth, and may be expressed along a nominal scale ranging from very useful (or even 'essential') through to useless. The degree of utility for any given source of LR information will depend on its purpose. This includes the original purpose for collecting the information, and/or the purpose for which the information will be applied.

A purpose may be general or specific. LR information for general purposes may include information concerning a number of land resources, or information for a single resource using a broad range of variables. Examples include land inventories and 'general soil surveys' respectively. Both are based on the premise that a broad range of information can be used for a large number of different purposes. However, they tend to be limited by their generality, in that they do not usually contain enough detailed information needed for intensive applications. In contrast, specific LR information tends to contain a high level of detail directly applicable to a given purpose (*e.g.* planning irrigation), but less directly-relevant information for other purposes.

Two higher-level purposes for collecting LR information include science and planning (decision-making). So called 'hard science' is concerned firstly with the generation of new knowledge and understanding, and requires highly objective information to prove or disprove theory. With LR information, scientists are sometimes accused of pursuing this purpose solely for the sake of science (*e.g.* Molloy, 1980; McKenzie, 1991; Dalal-Clayton & Dent, 2001). While the information may have high utility for scientific purposes, its immediate utility for decision-making and planning will be considerably less.

The main driving purpose behind most soil and land resource surveys is likely to have been some form of land use planning. Indeed, it is for this reason that descriptive scientific information is often translated into interpretive information, thereby improving its practical utility for use in planning and decision-making. However, interpretation is only one step in linking basic information to the purpose of planning. Before the full practical utility of LR information can be fully realised, it must be integrated with, and evaluated against, other considerations and types of information that may influence the planning and decision-making process. This complicated progression (from collecting basic LR information through to its use in decision-making) is commonly referred to as the process of land evaluation.

THE PROCESS OF LAND EVALUATION

The activity of assessing the fitness of land for a purpose is longstanding. This would have been expressed soon after the advent of agriculture (around 8000 years ago), probably as a passive realisation that some areas of land are more suitable for agriculture than others (particularly with shifting forms of agriculture). With greater familiarity and experience, there may have also been a gradual realisation that some areas behave differently under the same type of agricultural use (thereby necessitating different approaches to management), and that various crops will perform differently on the same area of land. Stationary forms of agriculture would have allowed this familiarity and experience to grow, and to be passed between generations as local or traditional knowledge. Over time, these passive forms of assessment allowed the development of successful agricultural systems and cultures.

The point at which land was first formally assessed is not known. While crude methods were certainly used by ancient civilisations (see extract below), the active mapping and assessment of land didn't really begin until the growth of science and industrialisation during the late 1700s. This is perhaps best characterised by the English agriculturalist Arthur Young (1741-1820), who undertook a series of agricultural investigations and tours of the British Isles, and is credited with having prepared some of the earliest surviving soil maps in the 1790s and 1800s (Dalal-Clayton & Dent, 2001).

> *'Now let me tell you how to distinguish the various soils. First mark a place with your eye and have a pit sunk deep in the ground, then put all the earth back again and stamp it level on top: if it fails to fill the pit, that soil is loose and fitted for generous vines; but if you cannot replace it all, and earth is left over after you've filled the pit, that land is a sticky glebe that'll need your strongest oxen to plough it'*
>
> Virgil: Georgics 2, 37-30 BC.
> (Cited in Dalal-Clayton & Dent, 2001, p.9).

Formal mapping of natural resources for various purposes continued through the 1800s and early 1900s, but didn't gain serious cohesive traction until after the Second World War (Dalal-Clayton & Dent, 2001). This includes the emergence of land inventorying and classification (Chapter 5), and the expansion of soil survey and its ensuant 'soil interpretations'. Both approaches were characterised as official government services that focused on systematic survey and widespread coverage, each with its own empirical methods of collecting and interpreting LR information (*e.g.* Hockensmith & Steele, 1943; USDA, 1952, 1954).

The development and application land resource survey and classification grew rapidly throughout the 1950s and 1960s, such that many countries had established their own characteristic systems by the early 1970s. With the advent of globalisation and international aid projects, this diversity made the exchange and comparison of LR information difficult (FAO, 1997). Attempts to develop an internationally consistent and applicable system eventually resulted in the design of the *Framework for Land Evaluation* (FAO, 1976). While the Framework has its own particular method, its introduction essentially popularised the concept of 'land evaluation' onto the world stage. Ideas of 'soil interpretations' and 'land classifications' were soon subsumed by the new concept (van Diepen *et al.*, 1991), and 'land evaluation' became a consistent and overarching term used to describe all methods of assessing the fitness of land for a given purpose.

3.5. LAND EVALUATION

Land evaluation is *the process of assessing the fitness of land for a given purpose*. Although being very broad and vague, this definition accommodates all conceivable purposes for undertaking an evaluation (intrinsic or utilitarian); all possible methods (from intuition to quantification); and the many overlapping components that can be included in a land evaluation process (from survey to land-use planning). It is also aligns closely with many other popular definitions (Figure 3.4), although in most cases it is considerably less descriptive.

There are a number of common features shared between definitions and applications of land evaluation. Firstly, land evaluation is undertaken for a reason or purpose. Secondly, the process represents a decision-making activity with its own distinguishing iterative steps and methods. Thirdly, it involves two forms of comparison: *land resource attributes* are compared against *land use attributes* (as land use requirements and impacts), and the actual use or performance of land may be compared against its potential use or performance (with the difference indicating opportunities for land use and management). Finally, a spectrum of different land evaluation methods and frameworks exist.

3.5.1 PURPOSES OF LAND EVALUATION

General purposes of land evaluation are sometimes expressed as aims or objectives. At the fundamental level, land evaluations are undertaken *to provide information* to decision-makers (van de Graff, 1988; Rossiter, 1994); *to assist, support,* or *guide* land users in decision-making (Burrough, 1989; Landon, 1991; Webb & Wilson, 1995; Dalal-Clayton & Dent, 2001); or *to predict* the consequences of land use change (Molloy, 1980; Dent & Young, 1981). In a strictly formal sense, land evaluation may also aim to provide a more rational or objective basis for decision-making (Sys *et al.*, 1991; Bouma *et al.*, 1993; Wilde *et al.*, 2002).

DEFINITIONS OF LAND EVALUATION

- The assessment of man's possible use of land for agriculture, forestry, engineering, recreation, etc. (Stewart, 1968).
- Land evaluation is assessing the value or usefulness of land for one or more uses of it (Gibbons *et al.*, 1968)
- The process of assessment of land performance when the land is used for specified purposes (FAO, 1976).
- The process of collating and interpreting basic physical and biological inventories of land, together with the social and economic factors, in order to identify and assess land use alternatives (Molloy, 1980).
- The process of estimating the potential of land for alternative kinds of use (Dent & Young, 1981).
- All methods to explain or predict the use potential of land (van Diepen *et al.*, 1991).
- Land evaluation is a general term embracing all forms of interpretation, and not implying any particular method of evaluation, or classification or final land use (Landon, 1991).
- The process of interpreting the opportunities and limitations presented by the relatively permanent biophysical factors of landscape topography, climate, geology, soil and hydrology, in relation to the requirements of specified land uses (Webb & Wilson, 1995; Wilde *et al.*, 2002).
- Land evaluation assesses the suitability of land for specified land uses (Beek *et al.*, 1997).

Figure 3.4: Popular definitions of land evaluation.

Purpose is also a function of a land evaluation's scope. For *physical land evaluation* (to be discussed) the general purpose is often to rate or classify different areas of land according to their capability, suitability, versatility, productivity or vulnerability/susceptibility according to one or more land uses. Such information can then be used in conventional forms of management and land use decision-making. Alternatively, a *comprehensive land evaluation* (also to be discussed) will go further by having an end-purpose directly related to land use planning and decision-making. This may include one or many purposes that aim to increase agricultural productivity, guide land purchase, minimise environmental impact, diversify land use, allocate competing land uses, and so on.

This means that land evaluation can be applied to virtually any form of land-based decision-making (*i.e.* decisions that concern land), and therefore a wide range of conceivable purposes at detailed scales. Accordingly, land evaluation may be applied to an individual farm, either for a specific purpose or for multiple integrative purposes. A specific purpose may be planning a fertiliser, effluent irrigation, or stock grazing programme. An integrative purpose may be whole farm planning that seeks to reconcile the multiple and often conflicting objectives associated with farm sustainability (Chapter 1: Section 1.7).

3.5.2 LAND EVALUATION COMPONENTS

Only three land evaluation components are considered here (Figure 3.5). Firstly, the process of *land resource survey* provides basic descriptive information upon which the land evaluation is derived. The types of LR information collected (*i.e.* the types of resources surveyed and types of attributes recorded) is ideally determined by the purpose and method of land evaluation, although 'blunderbuss' surveys (term from Dalal-Clayton & Dent, 2001) that collect a broad range of information types have often been used in the past. Government funded soil surveys in America and New Zealand are examples.

Land resource survey →	**Physical land evaluation** →	**Comprehensive land evaluation**
Collection of descriptive factual information Extended temporal relevance (decades to centuries)	Interpretation of descriptive factual information Requires land use information Evaluates land use attributes against land attributes Produces classifications or ratings of land capability, suitability, etc. Moderate degree of temporal relevance (years to decades)	Integrates interpretive information in planning & decision-making Requires socio-economic information Evaluates the socio-economic and environmental consequences of land use change Low degree of temporal relevance (months to years)

Figure 3.5: The three overlapping components of land evaluation.

Such practices have contributed to survey and land evaluation being managed as separate activities. The classic example is the distinction made between 'soil survey' and 'soil interpretations', whereby the latter activity is essentially synonymous with physical land evaluation. Despite this, there is a strong overlap between survey and evaluation (Dent & Young, 1981), due in part to the purpose-particular types of information that need to be collected for individual evaluations. Indeed, some land evaluation frameworks now explicitly include land resource survey as an integral component (*e.g.* FAO, 1976).

Physical land evaluation represents the mid-point between LR information and its use in decision-making. It attempts to 'explain or predict the potential of land for one or more uses by systematic comparison of the requirements of land use with the qualities of land' (Dalal-Clayton *et al.*, 2003, p.36). The end result being the production of various ratings, indexes, or classifications used to describe different areas of land according to their capability, suitability, productivity, etc. (for one or more targeted uses). It essentially represents a sophisticated comparison between the attributes of different areas of land, and the attributes of one or more targeted land uses. These *land use attributes* can be expressed as requirements (*e.g.* optimal conditions for plant production) and positive or negative impacts (*e.g.* nitrogen fixation by legumes, fertility transfer in pastoral grazing).

Physical land evaluation is concerned with the generation of information to support planning and decision-making. However, because land capability is only one factor in land use decision-making (albeit an important one), it must be integrated with, and considered against, the many other factors that will impact on the choice of land use and management. These include: *social considerations* such as lifestyle choice (*e.g.* working hours), labour, personal preferences, legislation, and other social responsibilities; *economic considerations* of profitability, capital investments, input expenses, financial risk and security; and *practical management considerations* such as access, water supply, and long-term maintenance (*e.g.* forestry pruning, weed & pest control).

Comprehensive land evaluation describes the formal process of integrating these considerations with the results from a physical land evaluation (*i.e.* physical land evaluation becomes a part of comprehensive land evaluation). It usually involves the generation of alternative land use options (or scenarios), which are then evaluated to determine feasibility and risk (*e.g.* through production modelling, economic analysis, or environmental impact assessment).

Although some prefer to distinguish this separately as the follow-on activity of 'land use planning' (*e.g.* Dalal-Clayton & Dent, 2001; Dalal-Clayton *et al.*, 2003), this can be confusing when used on its own, in that no foundation of land assessment is suggested. Occasionally the terms *integrated* or *integral land evaluation* are used (*e.g.* MacDonald & Brklacich, 1992; van Lanen *et al.*, 1992), and the underlying concept has long been implicit in ideas of whole farm planning, conservation farm planning, and more recent variations of comprehensive or environmental farm plans (see Chapters 5 and 6).

3.5.3 METHODS OF LAND EVALUATION

There are many different methods of land evaluation, and it is beyond the scope of this chapter to discuss them all. A general overview is provided below, along with several examples of how land evaluation has been formally applied in New Zealand. The greater range of methods and variants have been well described elsewhere (*e.g.* Stewart, 1968; Davidson, 1980; Dent & Young, 1981; van de Graaff, 1988; McKenzie, 1991; Sys *et al.*, 1991; Rossiter, 1994; Webb & Wilson, 1995; Dalal-Clayton & Dent, 2001; Dalal-Clayton *et al.*, 2003).

3.5.3.1 Informal land evaluation

Fundamental principles of land evaluation are inherent to informal land-based decision-making. This can be expressed as two distinctive but overlapping processes, which are regarded here as informal methods of land evaluation. They include trial & error and transfer by analogy (after McKenzie, 1991; McKenzie & Austin, 1992; Dalal-Clayton & Dent, 2001).

At one extreme, *trial and error* involves the application of land use options with little or no prior knowledge of the land. Land use options are generated intuitively, or are directly transplanted from having observed or experienced a land use being practiced in another location (as a crude form of transfer by analogy – see below). There is very little (if any) conscious assessment of land, and therefore a high degree of uncertainty and risk (in both environmental and production terms). Colonisation provides an example, where land uses that were well proven in a home country were assumed to be suitable for application in newly colonised lands.

Trial and error is also a compounding process, in that successful results can be retained and built upon, while failures (errors) can be discarded. It therefore represents a method for continually developing land use systems, and a method of accumulating a 'knowledge of the land' that can be shared between local communities and generations. Further, as a compounding process, new land use options or modifications can be developed and applied with a comparatively higher degree of confidence. For these reasons, trial and error is regarded as the oldest and most widely used system of land evaluation, and the default system used in the absence of more formal methods (McKenzie, 1991; Dalal-Clayton & Dent, 2001).

The limitations of trial and error are well recognised. Firstly, the risk of environmental degradation and production failure is high, particularly when 'knowledge of the land' is minimal. While the risk may be comparatively less in established systems (with accumulated knowledge), this only holds true if the rate of change is slow (*i.e.* when external conditions and the needs of people change only slowly). When the rate is high, new land use options/modifications must be generated and applied quickly to keep pace with the rate of change.

Experience gained from trial and error is not usually recorded. It can therefore be forgotten, and the mistakes of the past may then be repeated. Likewise, such knowledge may be lost if it is not transferred to those who need it most (*e.g.* to new farm managers), and in being local or site-particular knowledge, it may not be relevant to new areas (*e.g.* when managers move to new farms). Furthermore, such knowledge tends to have a low predictive value (because it can be difficult to clarify and organise), and may not be relevant to new problems or opportunities.

Transfer by analogy is the other main method of informal land evaluation, although in some contexts it may be synonymous with trial and error, and in others it may merge into more empirically formal methods. Transfer by analogy recognises that a land use practice or innovation from one site can be transferred to another site by way of land analogues (spatially dislocated areas of land that exhibit similar qualities). This means a land evaluation may be undertaken for one area, and the results can be assumed to be applicable to other areas because of similarities between land units (analogues).

Analogues may be represented by complete farms, whereby a single representative farm is targeted for demonstration or experimental purposes (*e.g.* focus farms, monitor farms, demonstration farms, experimental farms). In being representative, results from a study or trial (the analogies) are assumed to be relevant and applicable to other surrounding farms. In a similar sense, a farmer may observe or hear about a land use innovation developed on a local farm, and then apply it to his/her own farm on the assumption that both farms will have a similar type of land.

Analogues may also be landscape units, such as soils, landforms, land inventory or capability units, and perhaps even ecological units (*e.g.* ecological domains, land environments). Indeed, the 'transfer by analogy' concept has underpinned justifications for undertaking many land resource surveys (Dalal-Clayton & Dent, 2001). This is apparent in the history of soil conservation, whereby conservation management guidelines developed in one locale (the analogies), were transferred to other areas through the use of land capability analogues (Chapter 5).

The main limitation of transfer by analogy is that analogues have to be highly reliable. If they are not, then the process essentially reverts back to trial and error. This represents a difficulty for representative demonstration farms (particularly in highly variable landscapes such as NZ hill country), in that land-related results and findings can only be applied to other farms in a very general way.

Problems with landscape units are slightly different. Attaining a high degree of analogue reliability is a demanding and expensive task, to the point where it is often impractical to identify landscape units at a detailed scale (*i.e.* at farm and paddock scales where the majority of land use decisions are made most frequently). Further, there is a trade-off between the number of analogues that can be mapped, and the number of evaluations that are needed to adequately represent those analogues. As an example, while 100 representative landscape units may be identified, it may only be practical to undertake meaningful evaluations for a small number of units.

3.5.3.2 Formal land evaluation frameworks and methods

Land evaluation is more commonly discussed as a formal process undertaken according to structured methods and frameworks. These vary widely in terms of scientific rigour, ranging from empirical methods based on expert knowledge, through to complex process models that may seek to model the temporal and spatial dynamics of real-world systems in quantitative terms. Widely recognised land evaluation approaches with a degree of empiricism include: the Land Capability Classification; the FAO Framework for Land Evaluation (and its variants); parametric indices; and expert systems (after Dalal-Clayton & Dent, 2001).

The *Land Capability Classification* (LCC) has a long history as a standalone approach for physical land evaluation, and as the preliminary basis for comprehensive land evaluation through catchment planning and conservation farm plans (Chapter 5). While originating in the United States, the LCC has been widely adapted and refined, and is now routinely used in over 50 different countries (Stephens *et al.*, 1997). New Zealand has evolved its own variant as the Land Use Capability (LUC) Classification, and associated methods of catchment and farm planning. This system is detailed in Chapters 5 & 6, as it represents one of NZ's few land evaluation frameworks developed for pastoral agriculture at farm scales.

The *FAO Framework for Land Evaluation* (FAO, 1976) has also been applied widely on an international basis. In itself it does not represent an immediate method for implementing a land evaluation procedure, but rather puts forth a set of principles, concepts, terminology and guidelines that can be used to design a structured method tailored to suit local conditions and requirements. This has allowed widespread and consistent application of land evaluation according to the Framework's technically sound standards and procedures.

In NZ the Framework has found expression as Webb & Wilson's (1995) system of deriving 'land evaluation classifications' (*i.e.* physical land evaluations). They present a secondary framework of land characteristics and qualities considered relevant to productivity, crop quality, sustainability and land management as it applies to the NZ situation. Methods are put forward for the calculation of certain properties not readily measured (*e.g.* profile available water, profile permeability), and a rating system is erected for each characteristic based on objective criteria (*e.g.* Table 3.2). This framework is amendable to simple evaluations targeting one or two characteristics, through to complicated evaluations of suitability and versatility achieved by combining and weighting the ratings of several characteristics & qualities.

CLASSES & RATINGS FOR SOIL WATER DEFICIT OR SURPLUS

Deficit or surplus (mm)	*Class*	*Rating*
<100	Very low	1
100-200	Low	2
200-300	Moderate	3
300-400	High	4
400-500	Very high	5
>500	Extremely high	6

Table 3.2: An example of a rating derived from objective criteria (Webb & Wilson, 1995).

Webb & Wilson (1994) also developed a specific method of land evaluation for classifying land according to its versatility for orchard crop production (based on the framework discussed above). Likewise, Landcare Research and the National Institute of Water and Atmospheric Research (NIWA) collaborated to produce a series of land and climatic maps for the Tararua District (Wilde *et al.*, 2002; Tait *et al.*, 2002), many of which were based on Webb & Wilson's (1995) framework. These include descriptive maps derived from the NZ Land Resource Inventory (NZLRI) and National Soils Database (see Chapter 4), and 'interpretive maps' for soil versatility and soil suitability (for horticultural crops, cereal crops, and the 'grazing of heavyweight animals'). Similar physical land evaluations at district scales have also been recently undertaken as the *Grow Otago* and *TopoClimate South* projects (Chapter 4).

A less well-known approach to formal land evaluation is through parametric indices. This is similar to the idea of weighted classifications, in that a parametric index is derived by aggregating individual ratings for a number of land factors that have a bearing on land use. The *Storie Index Soil Rating* (Storie, 1978) is perhaps the most widely recognised. This system is based on four factors (Figure 3.6) that are subjectively scored as percents according to predefined criteria. Scores for each factor are multiplied to derive an overall percent rating.

SIR	=	**A**	x	**B**	x	**C**	x	**D**
Storie Index Rating		*Character of the soil profile*		*Topsoil texture*		*Slope*		*Miscellaneous factors*

Figure 3.6: Equation for deriving a Storie Index Rating of land.

Expert systems are also regarded as a formal approach to land evaluation. These are structured stepwise approaches that seek to capture the decision-making process of experts, often as decision-trees or sequential sets of if-then or yes-no statements. As an example, *decision-pathways* have been designed to facilitate the classification of land into LUC units for Northland (Harmsworth, 1996), Marlborough (Lynn, 1996), and the Gisborne-East Coast region (Jessen *et al.*, 1999). Each step in the classification procedure is flagged, and rules for making a decision are presented as questions based primarily on land inventory criteria. Responding to an initial question leads the user down a pathway of yes-no questions, that will eventually end as the identification of the most appropriate LUC unit.

Ascribing a relative degree of empiricism or objectivity to these different land evaluation approaches can be difficult. Not only can the degree vary between different steps in an evaluation process, but it is reasonable to suggest that many subjective measures and procedures can be replaced with objective counterparts. As an example, parametric indices are often criticised as being overly subjective-empirical methods, to the point where some consider them to be 'an evolutionary dead end in land evaluation' (Dalal-Clayton & Dent, 2001, p.149). However, a high degree of scientific rigour can be obtained by replacing the 'parameter' component with more objective measures and procedures. While this is readily achieved, the method is no longer regarded as a parametric index, but rather evolves in distinction to become a type of process model.

Process models seek to represent real-world processes and relations abstractly through scientifically defensible functions and equations (*e.g.* Figure 3.7). They tend to be based on well defined processes and measurable variables, although various degrees of empiricism seem to be unavoidable (McKenzie, 1991). A common example is the use of constants derived by statistically comparing model predictions with actual measures (of the factor being predicted).

Equation for calculating Structural Vulnerability Index (SVI)

$$SVI = 1 - [(DR/10 + PR/100 + \sqrt{OC}/5 + \sqrt{CL}/8.5 - 0.7)/2.3]$$

Where:
DR = Drainage class
PR = Phosphate retention (%)
OC = Organic carbon (%)
CL = Clay (%)

Figure 3.7: Example of a specific process model that can be used to evaluate the physical vulnerability of NZ soils to compaction or pugging (Hewitt & Shepherd, 1997).

Process models may be designed to represent specific physical processes (*e.g.* erosion, water movement, nutrient leaching), or more comprehensive processes relating to productivity, efficiency, profitability and environmental impact. Comprehensive models may also represent the linking of many different specific (sub) models. Numerous examples exist, including models for evaluating potential phosphate loss via runoff (*e.g.* Hart *et al.*, 2002), nitrate leaching and nutrient budgeting (*e.g.* Ledgard *et al.*, 2001), soil resistance to physical damage (*e.g.* Hewitt & Shepherd, 1997), and many others that seek to predict some relation between land use and land capability.

At the upper extreme of formal land evaluation, well-tested process models impart the highest degree of scientific rigour and confidence to land-based decision-making. They are transparent, reproducible/transportable (they can be applied in many situations with confidence), reliable, and highly defensible when decisions are contested. However, these benefits come at a cost, as such methods tend to require objectively measured inputs (as data), and their technical nature means that a specialist is usually required for application, processing and interpretation. Further, even the most sophisticated models are simplistic when compared against the dynamic complexity of the real-world, and in being reductionist, they cannot yet account for synergy and rapid or unforeseeable change.

At the other end of the formal spectrum, subjective-empirical land evaluation may accommodate some of these problems through human judgement, but this in-turn detracts from scientific rigour and reliability. The final numbers or results may seem to appear as if by magic; the underlying assumptions are often hidden; and the logic and reasoning can be difficult to retrace (Dalal-Clayton & Dent, 2001). Objective-empirical methods seem to offer the greatest compromise, particularly those that seek a high degree of scientific rigour, but acknowledge and rely on the human element when the pursuit of objectivity becomes impractical (*e.g.* variations of the FAO Framework).

LAND EVALUATION & PASTORAL FARMING

Pastoralism dominates NZ agriculture, and continues to make a significant contribution to the national economy and the well-being of New Zealanders. To remain dominant and successful, pastoral farmers must continually refine and develop their farming systems to accommodate change, but in a way that reconciles the many and often conflicting objectives of farm sustainability. Ongoing environmental problems (linked with pastoralism) suggests that some of these objectives are not being achieved. Obtaining and using LR information through land evaluation represents an opportunity for more robust and rational decisions concerning land, including the identification and evaluation of land use options that accommodate the many objectives of farm sustainability.

3.6. PASTORAL FARMING IN NEW ZEALAND

Pastoral farming dominates New Zealand land use. For the total NZ land area (26.8m hectares), approximately 39% is used for pastoral grazing; 7% for non-pastoral intensive uses (*e.g.* horticulture, mining, urban); and 54% can be considered as natural areas that include indigenous forest, bare rock, water bodies, and coastal margins (calculated from MAF, 2003). Pastoralism dominates 53% of total land area in the North Island (Figure 3.8), while in the South Island it is considerably less at 29% (although this does not account for all tussock high-country used for grazing purposes).

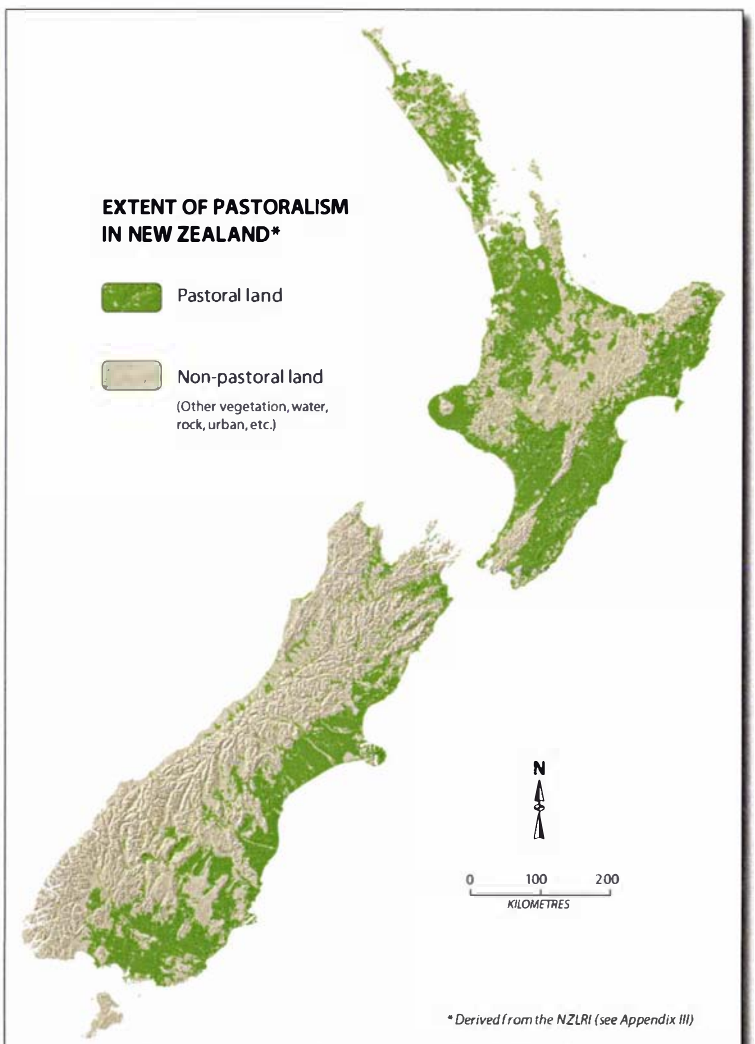

Figure 3.8: The distribution of pastoral land use in New Zealand as recorded in the NZLRI (see Appendix III).

The NZLRI is 10-20 years out of date. The total area of pastoral land has decreased over this time (by about 10-15%). However, even when Figure 3.8 is compared against more recent vegetation maps (e.g. from the Land Cover Database), it is difficult to discern where these changes have taken place (at this scale).

Pastoral dominance can also be expressed in property terms. Of the 70,000 various farms located throughout NZ, approximately 69% (48,430 farms) have a primary emphasis on livestock grazing (calculated from MAF, 2003). This equates to 32,000 pastoral farms in the North Island (69% of a total 46,500 NI farms), and 16,500 pastoral farms in the South Island (71% of a total 23,500 SI farms).

Pastoral agriculture also makes a significant contribution to the national economy. For the year ended June 2002, NZ's land-based industries (agriculture, horticulture and forestry) earned $20.6b in exports, which represents approximately 65% of NZ's total exports ($31.7b). On it's own, pastoral agriculture contributed $14.5b (46% of the total exports).

3.6.1 KEY ENVIRONMENTAL PROBLEMS OF PASTORAL AGRICULTURE

The challenges of modern-day agriculture have been briefly discussed (Section 3.1.1), and can be summed as a requirement to continually refine and develop farming systems in response to change, but in a way that reconciles the many objectives of farm sustainability. These objectives are multifaceted and often conflicting (Chapter 1; Section 1.7), particularly in regard to farmers' medium-term economic necessities (a farm must be profitable to survive), and their longer-term social responsibility to use and manage land in a way that does not unduly compromise its integrity (for future use), and in a way that does not impact undesirably on the wider environment.

The continued dominance and contribution of pastoral agriculture at the national level suggests that change is successfully being accommodated at the farm level, at least in economic terms. However, in environmental terms, there is evidence to suggest that many farmers continue to fall short of adequately fulfilling their responsibilities for using and managing land sustainably. This is frequently highlighted as *environmental problems, issues* or *concerns*, which for the most part involve undesirable land use impacts on soils, water, and on-farm natural areas.

3.6.1.1 Water problems

Intensive pastoral agriculture is frequently implicated with environmental problems concerning NZ's water resource, particularly in relation to the allocation of water for irrigation, and the contribution of pastoral agriculture to declining surface and groundwater quality.

Water allocation for irrigation has become particularly contentious in recent years, as the area of irrigated land has been increasing at a rate of 55% each decade (Lincoln Environmental, 2000). Much of this expansion has been in the South Island (70% of irrigated land is in Canterbury), and has increasingly involved dairy farming (amongst other forms of intensive agriculture). High levels of water consumption have resulted reduced water availability for other users and purposes, and reduced flows and volumes that have exacerbated water quality problems.

The impact of pastoralism on water quality is now mostly from diffuse sources (*e.g.* effluent disposal to land rather than water is now the norm), although direct defecation of livestock into waterways has recently been identified as a significant contributor (*e.g.* Parkyn *et al.*, 2002). The main problem is one of cumulative additions of contaminants (pathogens, nutrients, sediment, agrichemicals and nutrients) from many farms via leaching and surface runoff (including erosion), which in-turn contributes to groundwater contamination (namely nitrate and chemical), eutrophication, and water unsafe for consumption and recreational purposes. Such contributions are generally proportional to the level of pastoral intensification, particularly as they relate to livestock type (*e.g.* dairy cattle vs. sheep), stocking rates, and nutrient input (from fertiliser or supplement feed). However, they are also determined by inherent features of land (*e.g.* soils, geology & erosion, climate), and the way different areas of land are strategically used (*e.g.* riparian zones & stock exclusion, conservation tillage, shelter, conservation plantings).

The contribution of agriculture to NZ's water quality problem has been comprehensively studied by Smith *et al.* (1993) and Parkyn *et al.* (2002). They generally conclude that lowland rivers in agricultural areas are in poor condition due to high nutrients, turbidity and faecal contamination, all of which were strongly linked to the proportion, intensity, and types of agriculture practiced in river catchments. Rivers and streams in dairy farming areas are identified as having particularly poor water quality.

3.6.1.2 On-farm biodiversity problems

Approximately 70% of New Zealand's original forest cover has been cleared since human arrival (Figure 3.9), and a similar 70% of natural wetlands have been drained and modified (MfE, 1997; Leathwick *et al.*, 2003). A significant proportion of the remaining natural areas are sporadically fragmented across NZ's agriculturally used land. Froude (2000) and MAC (2000) estimate that up to 2m hectares of indigenous forest and wetlands is currently managed outside of the conservation estate, but it is not yet known (with any degree of confidence) how much of this occurs within pastoral farms.

While we may judge historical deforestation negatively according to contemporary values, it cannot be denied that it has allowed NZ to develop into an internationally competitive nation with high living standards. However, it has also resulted in widespread loss of habitat and the extinction of many plants and animals. Continued deforestation and development of wetlands is now considered to be undesirable, and considerable effort is being invested by national and regional government to protect and restore the remaining areas (see Chapter 2).

The practical economic worth of on-farm natural areas is small. Forest remnants and scrub may have some value as timber and shelter, and they may contribute to property value through aesthetics. However, they may also represent a cost (*e.g.* ongoing weed & pest control, fencing), or a production opportunity awaiting to be developed (*i.e.* yet undeveloped land for production, firewood resource, timber resource). Hence, while it may be wholly desirable to protect and restore on-farm natural areas from a regional and national perspective, it may be undesirable and impractical from a landholder's point of view. Generally farmers retain property rights over their natural areas, although some restriction is afforded under the Resource Management Act (RMA) if such areas are deemed to be significantly important in cultural, community or ecological terms.

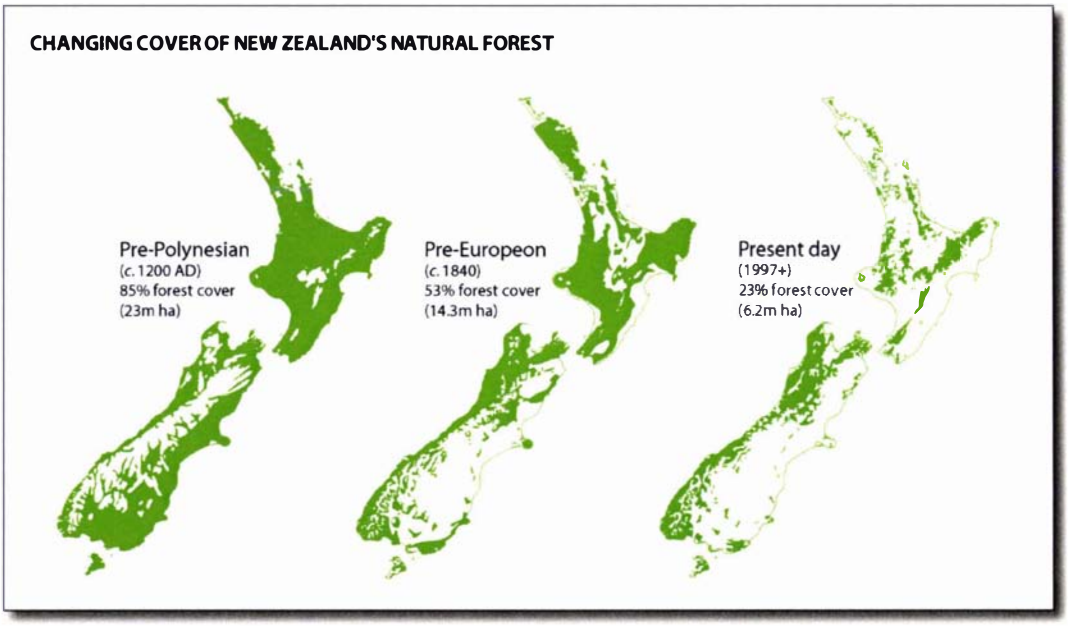

Figure 3.9: Historical changes in the cover of New Zealand's natural forest and shrubland (MfE, 1997).

3.6.1.3 Soil problems

Major soil problems associated with NZ pastoral farming include soil erosion, contamination, and compaction. Type and potential severity of erosion is an inherent feature of land, which has been accelerated through deforestation and pastoral intensification. For the total area of NZ pastoral land (12m ha), 35% exhibits no significant erosion; a further 35% is affected by surface erosion that can be ploughed (wind, sheet, rill); 27% by erosion not readily amended (*e.g.* slip, gully, and slump erosion); and 4% by sediment deposition and streambank erosion (calculated from the NZLRI[6]). As dominant erosion types, surface erosion is predominant in the South Island, while mass movement erosion appears to characterise pastoral North Island hill country (Figure 3.10).

In terms of erosion severity, 35% of erosion occurring on pastoral land is classed as being negligible; 51% is as slight; 11% as moderate; and 3% as severe to extreme. Severe to extreme erosion occurs sporadically throughout NZ, but it is notably concentrated in the eastern hill country of the North Island (with the greatest density occurring in the Gisborne-East Cape area). However, because the NZLRI is dated, it is likely that a significant proportion of the severest erosion has been ameliorated through the combined efforts of farmers and regional authorities over the past 10-20 years.

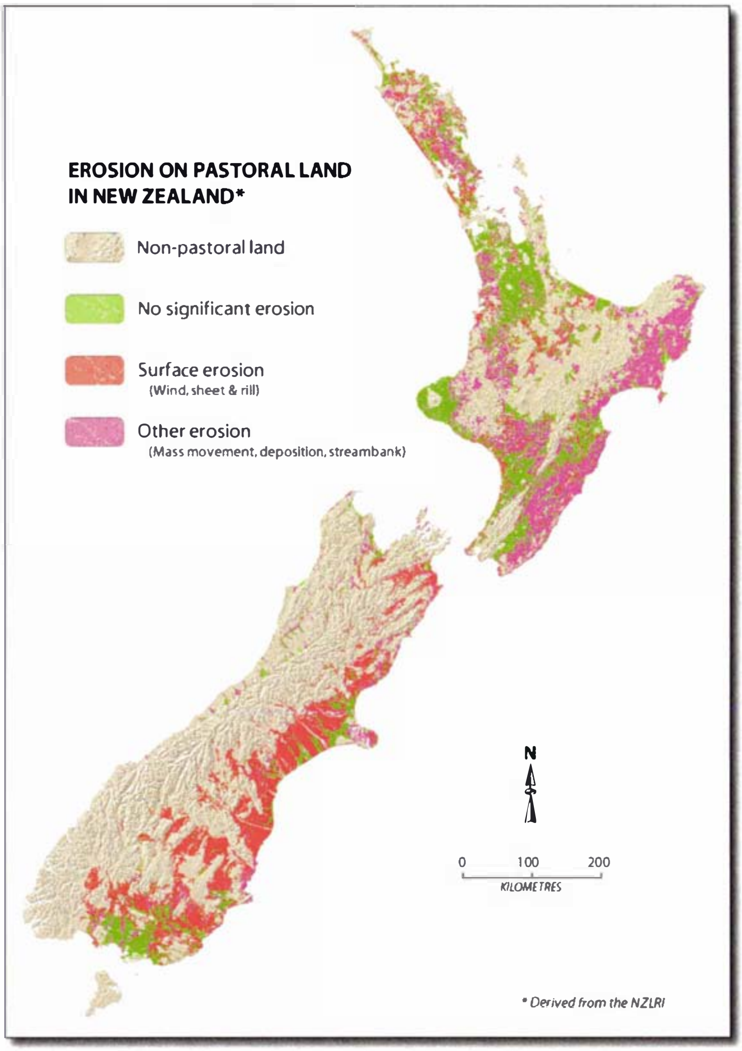

Figure 3.10: Types of erosion associated with NZ pastoral land. Derived from dominant erosion types recorded in the NZLRI.

[6] Calculations and erosion distribution derived from the dominant type of erosion recorded in the NZLRI (*i.e.* the type of erosion recorded first in the erosion code). It should be recognised that more than one type of erosion can occur in any given polygon, and that a recorded erosion type only very rarely covers the entire polygonal unit. It is more likely that erosion only occurs in parts of the polygon, meaning that calculated areas and distribution used here are unavoidably overestimated and partly misrepresentative.

Soil contamination relates mostly to chemical and heavy metal residuals, particularly cadmium and DDT metabolites. While levels in NZ soils are generally regarded to be low, both contaminants tend to bioaccumulate in livestock, and therefore represent a food safety risk. The extent of DDT contamination is difficult to estimate, because patterns of use between the 1940s and 1970s are largely unknown. It is assumed that there may be several-thousand potential 'hot spots' as old dipping sites (*i.e.* locations where livestock were treated for external parasites), and a more extensive contamination of areas with longstanding pastoral-insect problems (a common pre-1980s practice was to mix DDT with fertiliser to control porina and grass-grub through aerial topdressing).

The extent of cadmium contamination is more readily estimated, as cadmium levels in soil have been strongly correlated with the widespread use of phosphate fertilisers (Roberts *et al.*, 1994). They can also be strongly related to soil productivity (rate of breakdown) and anion retention capacity. Hence, drier pastoral soils with a significant inclusion of allophane and a reasonable fertiliser history are likely to have notable accumulations of cadmium.

Soil compaction in pastoral agriculture is most often expressed as soil pugging or treading damage caused by livestock. This occurs when the soil has insufficient strength to support the weight of animal traffic, particularly when soils are wet and overstocked. The result being a sealed layer (particularly when it dries), which restricts soil permeability for air, water, and freedom for root growth. Pugging by cattle has been associated with reductions in drainage, aeration, infiltration, water redistribution, and impaired moisture retention, along with increases in bulk density, surface ponding, runoff, and increased emissions of greenhouse gases (Mackay *et al.*, 1993; Ledgard *et al.*, 1996).

While pugging contributes to increased runoff and emissions in an environmental sense, it may also impact severely on farm production through reduced pasture growth. Repeated cattle pugging of a hill country soil can reduce annual pasture growth by around 30-40%, while a single event can result in immediate growth reductions that only recover after six months (Betteridge *et al.*, 1998a, 1998b; Mackay *et al.*, 1998). Pugging by dairy cattle may result in a 20-80% reduction in pasture production, which may last for 4-8 months (Ledgard *et al.*, 1996).

3.7. THE POTENTIAL OF LAND EVALUATION

Formal approaches to land evaluation offer a number of potential opportunities to NZ pastoral agriculture, particularly as they relate to reconciling the objectives of farm sustainability in a rational and defensible manner. These potential opportunities concern the collection of farm-specific LR information, its use to formally identify land capability (how can land be managed sustainably if we don't know what land is capable of sustaining?), and its integration into management decision-making and farm planning. Being able to realise these potentials is currently constrained by a number of interrelated factors.

3.7.1 THE COLLECTION & USE OF LR INFORMATION IN PASTORAL FARMING

What most NZ pastoral farmers know about their land is likely to have been gained through experience, familiarity, and other informal methods. While there are certainly exceptions (see below), this claim can be made on the basis that farmers as a group tend not to favour the formal collection and use of most forms of agricultural information (Section 3.1.2), and reliable LR information at meaningful scales tends to be rather scarce in NZ (to be discussed). Hence, by preference and default, the general collection and use of LR information in farm decision-making can be considered to be more of an informal rather than formal activity.

The main exceptions include information gained through soil testing, environmental farm plans, and to a lesser extent, occasional farm evaluations or surveys undertaken as a contracted service, or for research purposes. Soil testing provides very specific information concerning soil fertility (pH, CEC, availability of P, S, K, etc.), and may include reference to soil information recorded elsewhere (usually as names of the soils that are likely to occur on the farm). Such information has traditionally been collected and used for the very specific purpose of managing fertiliser inputs, although in recent years it has increasingly been used for nutrient budgeting and modelling for environmental purposes (*e.g.* Ledgard *et al.*, 2001; Hart *et al.*, 2002). While the extent of regular soil testing in NZ is unknown, it is generally regarded to be a mix of regular testing on 2-3 year basis; irregular testing for occasional purposes (*e.g.* land development); and in some cases an outright absence of testing.

Environmental farm plans evolved from techniques based on the collection and use of LR information on a farm-by-farm basis (Chapter 5), and should therefore represent a consistent and reliable source of information for farm decision-making. However, developments over the past 10-15yrs have not been monitored on a national basis, and there exists a degree of uncertainty about the state of modern-day environmental farm planning in NZ (Chapter 6). Even less is known about the extent of once-off farm-scale soil surveys and evaluations, which have been undertaken sporadically throughout the years by contracted specialists and researchers (Chapter 4).

Farmers' apparent predisposition towards informal land evaluation is not necessarily a disadvantage or limiting factor. Some of the advantages of informal decision-making have been discussed (Section 3.1.3), and it can be argued that farmers have a location-particular understanding of their land that can be more useful than LR information derived through survey and formal land evaluation. This is recognised as 'a valuable store of practical knowledge about soil [and land] behaviour' (Cutler, 1977, p.3), which has value to both soil surveyors (*ibid.*) and those involved in soil conservation surveys (Chapter 5). Indeed, Dent & Young (1981) state that farmers 'may already have a far better knowledge of their own soils [and land] than the surveyor is likely to acquire' (p.5).

Provided land use on a given area of land remains unchanged, then it is unlikely that a farmer has any real need for LR information and formal land evaluation (Dent & Young, 1981; McKenzie, 1991; Dalal-Clayton & Dent, 2001; Dalal Clayton *et al.*, 2003). However, ongoing change is a characteristic of modern-day agriculture, and the relocation of farm managers to new or different properties is common practice (*e.g.* buying and selling a farm, share-milking, leasing land). In both these situations, formal LR information and land evaluation can have either a complementary value, or even an outright higher value to farmers' knowledge and informal decision-making processes.

3.7.2 POTENTIAL BENEFITS FOR A RELOCATION OF MANAGEMENT

LR knowledge is not considered transferable to a new farm that has a significantly different combination of land resource types and qualities (McKenzie, 1991; Dalal-Clayton & Dent, 2001). Put another way, the LR knowledge of a potential new land owner or manager is likely to have little relevance to the farm he/she is about to purchase or manage. Hence, there is a high element of risk and uncertainty, particularly in relation to the considerable investment required for the purchase of land, and the long-term commitment associated with farm management. Quality LR information provides a factual and reliable means upon which a farm purchase or management change can be based.

Provided a new manager continues the previous system of land use, then the risk of failure or error is small. However, as often is the case, a manager will seek to try something new, such as a land use refinement (*e.g.* intensification), land development, or the application of a completely new system of land use. In the absence of local LR knowledge, the risk of failure or error is comparatively higher, as the new manager may not foresee or predict undesirable outcomes of land behaviour and response (*e.g.* poor productivity, environmental degradation, etc.). The previous manager may have been able to do so because he/she has experienced land behaviour under different conditions and management. Formal LR information and land evaluation represents a method of not only shortcutting these experiences, but also of adding a higher degree of confidence to the decision-making process (see below).

3.7.3 POTENTIAL BENEFITS FOR EXISTING MANAGEMENT

The potential benefits of land evaluation to existing management can be examined on two levels. Firstly, the information used and generated by a land evaluation process has value as a record for planning, communicating, and justifying decisions. Secondly, the process itself can convey a number of benefits relating to the soundness of a decision, and can therefore convey a higher degree of confidence to the decision-maker.

3.7.3.1 Benefits of LR information

LR information is a formal record of land resources and their attributes as they vary across the landscape. While such information varies in scientific rigour according to methods of collection and generation, it has a number of general advantages over tacit knowledge and other forms of informal and unrecorded information.

Firstly, recorded LR information has value towards communication & decision justification. This may represent the communication of a farm's land character to a service provider to assist in decision-making, such as a farm consultant, regional council officer, or fertiliser representative. Such information carries the advantage of being readily available and comparatively more complete, relative to the amount and type of information that a farmer may be able to recall and express while communicating with service providers.

Similarly, formal LR information can more-readily be used to defend a contested land decision, or to support an application to a regional authority for a land use change. Further, favourable LR information can be used to market a farm to potential purchasers, and to demonstrate the attainment of production standards required by various Quality Assurance Programmes (Chapter 6).

Secondly, formal LR information has value for management decision-making. This may include some form of monitoring, whereby the existing land condition is identified and compared against either a desired state (*e.g.* a natural or 'healthy' condition), or a changing state (*e.g.* monitoring the impact of a land use change over time). In recent years this has gained recognition as environmental monitoring through the use of indicators. This involves the ongoing assessment and comparison of key land qualities (indicators) according to acceptable upper and lower thresholds. A significant deviation outside of accepted values indicates a problem that needs attention. A practical example is the monitoring of soil fertility levels to manage fertiliser inputs.

Using LR information for management may also include the identification of production limitations of land through survey or soil testing (*e.g.* impeded drainage, trace element deficiency, high acidity, high phosphate retention capacity). Limitations that can be overcome through management and development can become production opportunities (provided they are economically and socially acceptable), while more permanent limitations must be accommodated into the land use system design.

This feature can be extended to include the identification of potential problems as land-use induced limitations. Using physical land evaluation, different areas of land can be rated according to their potential vulnerabilities and susceptibilities. Such ratings are derived from known qualities of land, which are used to predict the likely response of different areas of land to a change or intensification in land use. A number of land vulnerabilities have a high relevance to pastoral farming (Figure 3.11). Reliable land evaluation methods for assessing these potentials are readily available (many as process models), and it is feasible to suggest that a competent service provider could generate this type of LR information for farm decision-making.

POTENTIAL LIMITATION RATINGS OF RELEVANCE TO PASTORAL FARMING

- Soil vulnerability to livestock pugging.
- Erosion susceptibility.
- Potential for pest infestation (particularly with newly introduced insects & weeds).
- Risk of waterway contamination through surface runoff.
- Leaching potential.
- Potential for toxicant accumulation in soil.

Figure 3.11: Induced or accelerated 'potential limitations' of land that have a strong relation with intensive pastoral farming.

Information derived through physical land evaluation can also be used to identify opportunities for intensification, diversification, and reconciliation. Along with the identification of management limitations, productivity potentials (*e.g.* optimal yields, stocking rates) can be predicted for different areas of land and compared against actual performance. A positive difference represents a problem (land is being used outside its potential), while a negative difference represents an opportunity for intensification. Likewise, the assessment of potential suitabilities and versatilities of different land uses (*e.g.* suitability of land for effluent disposal, different fodder crops, etc.) can be used to identify options for improved land management, or for a significant diversification in land use.

Perhaps the greatest benefit is when all these types of information are brought together for planning. This may include the allocation of land for competing land uses, such as retiring and protecting a farm's natural or least-productive areas, in favour of intensifying more-productive areas identified as having sub-optimal production performance. Alternatively, new land uses with a higher production potential and a lower environmental impact potential can be identified as options for further consideration. These potential changes can be further evaluated in terms of feasibility and risk (*e.g.* economic evaluation, environmental impact assessment), to identify a system of land use that accommodates the many objectives of farm sustainability. Taken together, expensive or land-degrading errors in land management and farming can be avoided through the use of LR information and land evaluation in farm decision-making.

3.7.3.2 Benefits of the land evaluation process

In addition to the generation of information for the purposes above, more-formal processes of land evaluation also carry a number of benefits for the decision-making process itself. Firstly, as formal land evaluation is based upon repeatable and tested methods, it is reasonable to expect that resulting decisions will be more rational (they will carry less bias and fewer assumptions) than informally derived decisions.

Secondly, a higher degree of decision-making clarity and transparency is afforded through the stepwise nature of formal land evaluations. Amongst other things, this has value towards communication; demonstrating rationality (as part of justifying a decision); systematically working through complex problems and decisions; and for returning to a step in a process after a period of time (*e.g.* to identify why a decision may have gone wrong, or to continue a decision process or analysis over an extended duration).

Thirdly, a greater degree of decision confidence could be expected from formal land evaluation. That is, all practical steps have been taken to minimise risk, thereby ensuring that a decision will be environmentally sound, socially responsible, and socio-economically successful. While this can only be true when a decision is based on quality information and a reliable system of land evaluation, it is feasible to suggest that increasing degrees of formality (ranging from intuition to process modelling) would relate strong to an increasing degree of decision confidence.

3.7.4 CONSTRAINING FACTORS

Despite the potential benefits discussed above, the use of LR information and land evaluation in decision-making is constrained by a number of well recognised factors. Like many other potential users, farmers may be *unaware* of the potential benefits of land evaluation; they may be *unwilling* to obtain and use LR information; and they may be *unable* to obtain reliable information, or make use of it in their decision-making processes.

In an international context, these constraints have been well-documented as they relate to users at a number of organisational hierarchies (*e.g.* McKenzie, 1991; Dent *et al.*, 1994; Dalal-Clayton & Dent, 2001; Dalal Clayton *et al.*, 2003). Dalal-Clayton & Dent (2001) provide a comprehensive summary of these constraints (Figure 3.12), and characterise the situation from a user's perspective: "What I'm wanting, I'm not getting. What I'm getting, I'm not wanting" (p. 377). From a specialist perspective, 'we have been pouring information into the sand' (p. 379).

CONSTRAINTS TO THE USE OF LAND RESOURCE INFORMATION IN DECISION-MAKING

∴ LR information is not in a form suitable for decision-making. Interpretations may not be specific to the needs of a user, and descriptive information has no sure place in users' decision-making processes.

∴ There is a gap between the scale at which information is needed and the scale at which it can be provided efficaciously (quickly, economically, and to an appropriate quality).

∴ Existing sources of descriptive information are of variable quality, detail and coverage.

∴ It can be difficult to disentangle primary factual data from interpretations.

∴ There is a critical shortage of competent land resource specialists able to provide LR information and land evaluation services.

∴ Local LR knowledge is often ignored by technical specialists. Conversely, it's value may be over-emphasised, in a way that overshadows the use and benefits of formal LR information.

∴ LR information is often incomprehensible to users: confounded by jargon & fogged by a shear mass of data.

Figure 3.12: Internationally recognised constraints to the use of land resource information in decision-making (adapted primarily from Dalal-Clayton & Dent, 2001).

Molloy (1980) provides a NZ perspective on these constraints (Figure 3.1.3), by listing and discussing problems that have existed between those who provide LR information (scientists, researchers and specialists), and the intended end-users of such information (namely planners, policy makers and land users). While the structure and emphasis of NZ science has changed significantly since the early 1980s, many of these constraints have persisted to the modern day.

PROBLEMS BETWEEN PROVIDERS AND USERS OF LAND RESOURCE INFORMATION

- Multiple sources of LR information are collected and held by different organisations. There may be an overlap in information types, and the compilation, integration & evaluation of information from different sources may take an extended period of time.
- Information is stored in different forms, which prevents ready integration & compilation, and inhibits access to information by end-users.
- Information may not be in an appropriate form. Interpretations may not be specific to a user's needs, and descriptive information may be unsuitable for immediate use.
- Reliability of information varies. Variation in accuracy, detail, quality and coverage may not be understood, noticed, or taken into account.
- There is often a temporal incompatibility between the time in which a decision must be made, and the time it takes to obtain and use LR information.
- Information providers may not be fully aware of the information needs of end-users. Likewise, end-users may not know the type and form of information they need to make a decision.
- End-users may not know where to source LR information from.

Figure 3.13: Recognised problems between specialist providers and end-users of land resource information (adapted from Molloy, 1980).

In a more specific way, Mackay *et al.* (1999) highlighted some particular constraints to the greater use of LR information in pastoral farming. These emerged from the Sustainable Land Management Project, as a result of having to obtain and use detailed LR information for the evaluation of two pastoral farms (Chapter 5; Section 5.4.4). They developed a somewhat novel method of land evaluation, which they considered to be suitable for wider extension and application. However, they also identified a number of 'barriers' to any widespread adoption, including the general unavailability of LR information; the lack of information at appropriate scales; the high cost for obtaining new information; and the difficulty of using such information because of the way it was packaged (*i.e.* inappropriate form of information).

Related studies subsequently summarised and expanded these constraints, through the development and application of the Soils Underpinning Business Success Programme (Chapter 7). Additional constraints included: a lack of applied examples that demonstrate practical land evaluation benefits; the ability of farmers to interpret and integrate soil information into planning; and the apparent lack of 'a general framework to assist with the integrated use of soil information for farm planning' (Mackay et al., 2001, p.79).

Two further constraints can be added. The first is farmers' apparent predisposition and preference for informal approaches to land evaluation, which in itself represents a significant barrier to a greater use of LR information in farm decision-making, and the adoption of more-formal approaches of land evaluation. Farmers may simply be disinterested in learning and applying formal decision-making processes, irrespective of any potential benefits.

The second expands beyond the farm gate and into society's higher hierarchies. Over the past decade there has been a gradual withdrawal of government support for land-based sciences related to agriculture, perhaps best measured by reducing levels of research funding to many of the applied biophysical sciences. As a result, there is now a decidedly limited number of specialists capable of undertaking land evaluations for farmers, and few funds to support new research and surveys at scales suitable for farm decision-making. In the absence of new information, innovations, and support, farmers are increasingly required to accommodate the challenges of sustainable farming through a default of informally derived information and land evaluation processes. And yet, politicians continue to wonder why land is not being managed sustainably.

The following chapters explore many of these constraints in greater detail. Chapter 4 represents an assessment of the state of NZ's LR information for pastoral farming, and options available to farmers for obtaining new information. Chapters 5 & 6 examine the potential of environmental farm plans as both a source of farm-scale LR information, and as a pastoral orientated method of land evaluation (from an historic and contemporary perspective). Chapter 7 reviews the application and effectiveness of a recent sustainable farming initiative, which seeks to overcome many land evaluation constraints by up-skilling farmers in the collection and use of LR information as it relates to their own farms.

SUMMARY

While farm sustainability is a function of the inherent and modified capabilities of land, it is the farm manager's decisions concerning how land is to be used that ultimately determines whether farm sustainability will be achieved. This is an ongoing requirement, whereby management must continually adjust the system of land use in response to internal and external change, and in a way that optimises land capability to fulfil socio-economic objectives, but without compromising land integrity or impacting on the wider environment in a socially unacceptable manner.

The ability of management to make sound and responsible decisions concerning land and its use, is strongly dependent on the quality of information used in the farm decision-making process. There is a general consensus that farmers are not receiving agricultural information that is relevant, affordable, timely, understandable and reliable, which in-turn is regarded as a constraint to sustainable management.

Effective decision-making is also determined by the manner in which new information is collected and used. NZ farmers appear to exhibit a preference for informal methods of assessing and monitoring farm performance, and the application of informal decision-making processes. Informal approaches are important for successful farm management, but they may lack the transparency and objectivity that is increasingly required for modern farming. To better accommodate modern-day challenges, traditional approaches to farm management need to become more formal, strategic, knowledge-intensive and information rich.

Land evaluation is the decision-making process of assessing the fitness of land for a given purpose or use. A lack of reliable land resource information, coupled with farmers' apparent predisposition towards informal decision-making, means that most NZ farmers rely on informal approaches to land evaluation (*e.g.* transfer by analogy, trial & error) by preference and default. More formal land evaluation frameworks exist, but vary in scientific rigour, technicality, and cost.

Pastoral farming dominates land use in NZ. While pastoral farmers appear to be achieving the socio-economic objectives of farm sustainability, ongoing environmental problems relating to soil, water and on-farm natural areas suggests many continue to fall-short of fulfilling their wider-social and environmental responsibilities.

More-formal approaches to land evaluation represent a means of reconciling the many objectives of farm sustainability. The ability of land to sustain one or many uses can be identified as opportunities and limitations (land sustainability or capability), and used to generate land use options that optimise production, allocate competing land uses, and accommodate land limitations and use impacts. Such options can then be further evaluated to determine risk and feasibility.

Potential benefits of more-formal approaches to land evaluation arise when a farm manager relocates to an unfamiliar property, or when changing needs or external pressures necessitate a review of the land use system. Both situations are common to pastoral agriculture. Potential benefits can be summed as increased transparency, rationality, and confidence in decision-making, which is important for communicating to service providers and others; defending or justifying land and land-use decisions; and planning a sustainable system of land use that seeks to minimise the risk of economic failure and environmental impact.

Constraints to a greater use of formal land evaluation in pastoral farming mostly concern land resource information. Either the information is unavailable due to problems of scale and coverage; it is unreliable in terms of quality; or it is presented in a form that is incomprehensible or inappropriate for decision-making. New information is generally expensive, and there can be a temporal incompatibility between the duration of decision-making and the time required to collect and use land resource information. There is a lack of specialists capable of obtaining and interpreting land resource information as a service, and a lack of examples that demonstrate the practical benefits of farm-scale pastoral land evaluation. From another perspective, farmers themselves may not have the skills to use and integrate land resource information into farm planning. Likewise, their apparent predisposition towards informal decision-making may represent a constraint to the adoption of more formal approaches to land evaluation irrespective of any potential benefits.

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Chapter 4

SOURCES OF LAND RESOURCE INFORMATION
FOR
SUSTAINABLE FARMING

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INTRODUCTION

Formally recorded land resource information (LR information) abstractly describes the character and condition of natural resources (*e.g.* soils, geology, ecology, hydrology, vegetation, etc.) as they vary across the landscape. It may also describe the capability of land to support optimal land uses, or conversely, the vulnerability or susceptibility of land to various land use impacts. Such information has value to pastoral farming, because it can be used to communicate, demonstrate, and plan farm sustainability in a rational (*i.e.* factually without bias) and reliable manner (Chapter 3).

LR information has been historically collected in New Zealand as maps of soils, geology, vegetation, topography, ecology, and land inventories, and their associated reports and bulletins. More recently, such information has been recorded in digital formats, either as data for use in Geographical Information Systems (GIS), or as standalone Land Information Systems (LIS). An almost bewildering array of published and readily obtainable LR information is available, but varies widely in its coverage, quality, and overall usefulness to farmers.

One particular source of published LR information finding increasing use in farm decision-making is soil information derived from the NZ Land Resource Inventory (NZLRI). This is despite being recorded at a 1:50,000 scale (widely considered to be unsuitable for application at farm scales), and a number of limitations associated with the manner in which the soil information was originally derived.

In recent years there has also been a steady emergence of new technologies and supporting agencies that specialise in the collection and recording of LR information. In the likely situation where published LR information is unavailable or unsuitable for farm decision-making, farmers now have a number of options for investing in new LR information particular to their own farms. This can be an expensive undertaking, depending on the type and detail of information required for particular farming purposes.

The aim of this study is to qualify the value of LR information sources and services for pastoral farm decision-making. Specific objectives include:

- Undertake a review assessment of published and readily obtainable LR information in NZ, to qualitatively evaluate which sources have a likely utility towards pastoral farming in terms of information relevance and reliability.
- Identify the types of survey tools, resources and services commercially available to farmers interested in obtaining new LR information.
- Determine alternative 'best option' combinations available to pastoral farmers interested in obtaining new LR information.

PUBLISHED & READILY OBTAINABLE LAND RESOURCE INFORMATION

Published or readily available LR information is that which can be obtained by the general public. This includes various map collections and databases concerning soils, geology, vegetation, topography, ecology, and land inventories, along with their associated reports, bulletins and memoirs. It does not include information that is held privately, is commercially sensitive, or is in someway restricted for public use. Public collections and databases may represent historical records that still remain relevant to modern-day resource management (*i.e.* they have extended temporal relevance), or active records that are continually being updated through survey, remote sensing, and other forms of LR information collection.

Numerous map collections and databases exist in New Zealand. In the early 1980s, Molloy (1980) reported 53 'major national inventories of map-related physical and biological data', which for the most part included the 40 types of 'land and water resource surveys' described by Clarke (1982) for the same period. In the mid-1980s, these and other 'geographic data systems' were summarised as a directory (LINZ, 1986), which reported approximately 80 different data categories with a direct relevance to land resources and/or agriculture. Statistics NZ published an 'inventory of environmental data sources' (Sheerin, 1992), which listed and described 64 data collections explicitly related to land, and approximately a further 20-30 with an indirect relation via agriculture and conservation. This was updated in 1998, and is now available online at www.stats.govt.nz . The most recent account is given by Froude (1999), who reviewed the 28 main 'national databases for land, water, freshwater biodiversity and terrestrial biodiversity' as part of an environmental indicators programme.

Not all these sources of LR information are appropriate for use in pastoral farming. Many vary in terms of geographical coverage, scale, accessibility, reliability, and overall relevance to the purpose of pastoral farm planning.

4.2. METHOD

A two tier method of evaluation is used. Firstly, a precursory assessment was undertaken by examining database and map-collection descriptions summarised by the authors listed above. Each database and collection was considered in terms of its potential relevance to farm management and sustainable farming (*i.e.* from an 'inside the farm gate' perspective). Those considered to have low or indirect relevance were discarded, thereby allowing the construction of a manageable array of information sources deemed suitable for more detailed evaluation.

The second evaluation was undertaken by qualitatively comparing information characteristics against predefined criteria. This involved the establishment of relevant criteria, and the design of a form template that could be applied to evaluate each information source. The method adopted is similar to that used by Froude (1999), differentiated by a focus on information for pastoral farm planning rather than for environmental monitoring and reporting.

'Relevant criteria' were identified according to known limitations of LR information (Chapter 3), and according to the potential utility the information may hold towards pastoral farm planning. Criteria were later condensed and structured into ten form fields for easier and more concise reporting (Figure 4.1). Selection and definition of criteria is discussed as a background review.

Criteria	Description
Abstract	General description of the information source.
Geographical coverage	An estimation of the geographical coverage on a national basis.
Method of collection	Overview of the methods used to collect/survey, analyse or interpret the land resource information.
Information types	Summary of the types of land resources represented; types of attributes recorded; and a distinction between descriptive and interpretative information if necessary.
Scale	Original scale or resolution at which the information was collected or captured (if possible), and the scale at which the information is presented.
Reliability	Known estimates of information quality in terms of attribute variability, map purity, positional accuracy, observation density, and scientific rigour.
Accessibility	Description of available information formats and media; sources of the information; and those responsible for overseeing the management of the information (custodians & stewards).
Strengths	Key characteristics of the information source that convey a high value to its use in pastoral farming.
Limitations	Key characteristics of the information source that limits its value towards pastoral farm planning.
Relevance to pastoral farming	Summary of how the information is or can be used in pastoral farming.

Figure 4.1: Template structure used to examine and report on public LR information databases and collections.

Twelve different types of published and readily available LR information were nominated as being potentially useful to the NZ pastoral farmer, many of which have a strong focus on soil resources. Each of these sources has been evaluated and reported according to the criteria presented above (*i.e.* in template form). This has included examinations of the information itself (where possible); examples of how the information has been used or applied; and descriptions of the information provided in various papers and reports.

The method used is wholly qualitative. While more scientifically rigorous methodologies are available (*e.g.* Forbes *et al*., 1982; McCloy, 1995), these were deemed to be too time consuming to apply to all twelve information sources in a reliable manner. Furthermore, some digital databases and non-map related information sources were not readily amendable to evaluation using these methodologies.

Difficulties were also experienced obtaining a complete level of detail required to fulfil the predefined criteria. Either the detail does not exist (particularly with estimates of information reliability and quality), or it was not readily accessible for appraisal. Further, some of the databases used to calculate statistics and distribution are not the most up-to-date versions available (obtaining such versions would have involved a considerable cost).

4.3. CRITERIA FOR INFORMATION RELIABILITY & RELEVANCE

4.3.1 INFORMATION RELIABILITY

Although being somewhat amorphous, the term *reliability* is used here to provide an indication of how confidently LR information can be obtained and used when it is needed. It must be available in terms of geographical coverage and accessibility, and at a level of detail and standard of quality that is appropriate for farm planning and decision-making. Four composite categories of information-reliability are recognised here as baseline criteria for evaluating existing LR information sources for use in pastoral farming.

4.3.1.1 Geographical coverage

Geographical coverage identifies the extent that a given source of LR information represents in areal terms. Sources with localised coverage have a low potential reliability, as the information can only be applicable to a select few farmers. Conversely, national coverage means that all farms are represented by the information. In this case, the information is reliable in that any farmer can be confident that he or she can potentially acquire the information when needed.

4.3.1.2 Scale

The reliability of spatial LR information varies with the scale or resolution at which the information is collected and presented. This is a function of cost versus the level of detail required for a given purpose, whereby costs generally rise relative to increasing detail (Beckett, 1968). The level of detail required for the purpose of farm planning is high when compared against the level of detail required for other planning purposes (Figure 4.2).

An appropriate scale for farm LR information is dependent on a number of factors. Firstly, it is important that landscape features relevant to farm management can be identified, either as a direct basis for planning, or as references for resource surveys. This includes the clear identification of roads, buildings, yards, fencelines, and perhaps even down to individual troughs and tree plantings. Generally, aerial photos at scales of around 1:10,000 or greater are sufficient for this purpose.

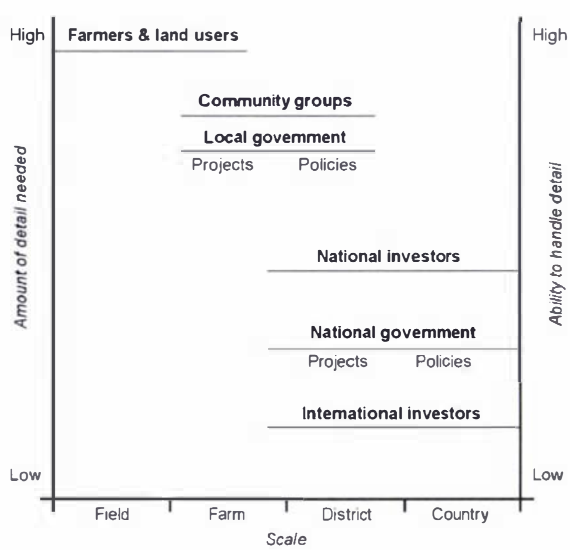

Figure 4.2: Relative level of detail required for different purposes at different scales (Dalal-Clayton & Dent, 2001).

From a resource management perspective, the appropriateness of scale is often determined by the size of the smallest land unit or polygon that needs to be delineated. Within the landscape, this is defined as the smallest unit of land that can be managed in a way that is different from the of surrounding units (*i.e.* the smallest *land management unit*), which translates to various physical *mapping units* in a land resource context (*e.g.* the smallest soil unit, landscape unit, inventory unit, etc. that can be differentiated).

When the smallest land unit is abstracted for presentation on a map or image, it becomes the *minimal legible delineation* (MLD), *minimal mapping unit*, or the *minimum size delineation* (Forbes et al., 1982; Gunn *et al.*, 1988; Reid, 1988). The MLD is the smallest legible map unit that can be labelled internally, and is conventionally defined to be a roughly circular area of $0.4cm^2$ (Figure 4.3). Hence, if the smallest area of land for a given management purpose is known, then the MLD can be used to calculate an appropriate scale for map presentation (Table 4.1).

Figure 4.3: Actual size of the minimum legible delineation ($0.4cm^2$) as different polygon units. This is the smallest area that can be legibly shown on a map (after Forbes et al., 1982).

Smallest area of land	Smallest legible map unit	Appropriate scale
0.1ha	$0.4cm^2$	1:5,000
0.4ha	$0.4cm^2$	1:10,000
0.9ha	$0.4cm^2$	1:15,000
1.6ha	$0.4cm^2$	1:20,000
3.6ha	$0.4cm^2$	1:30,000
10ha	$0.4cm^2$	1:50,000
16.1ha	$0.4cm^2$	1:63,360

Table 4.1: Examples of appropriate scales determined by the smallest area of land that needs to be shown on a map, and the smallest map area that can be legibly delineated as a unit (after Forbes et al., 1982).

The smallest management unit in pastoral farming is often regarded as the paddock. Accordingly, if the smallest paddock size for a dairy farm was 0.4 ha, then an appropriate scale of spatial LR information would be 1:10,000. Similarly, a hill country farm with a minimum paddock size of 4ha would require a scale of around 1:30,000. However, certain management activities can sometimes be undertaken at sub-paddock scales (*e.g.* break-feeding, effluent application, fertiliser application, strategic sowing, erosion control via space planting). Further, many non-pastoral areas smaller than the minimum paddock size may require a different approach to management by default (*e.g.* riparian zones, wetlands, other natural areas, shelterbelts). Taken together, this means that the smallest paddock size is not necessary the most appropriate unit from which the scale should be derived.

Another factor in the choice of an appropriate scale is practical convenience. For the purposes of survey, information use and management, it may be more convenient to have LR information at a scale unrelated to the required level of detail. As an example, a farmer with a particularly large property may opt for a less detailed map (or photo), simply because a more detailed example would be unwieldy in size (or number of maps). This factor may be particularly influencing during farm surveys, when it is more convenient to have a single base-map of a manageable size.

Different scales may also be used for both the collection and final presentation of LR information. Dent & Young (1981) suggest that field survey should be conducted on base maps that are 2 to 2.5 times more detailed than the scale of intended publication. This was common practice for many of the soil surveys undertaken in NZ, particularly with surveys at 1:31,680 being published at 1:63,360. Such a practice improves information quality (see below). It is also feasible to suggest that such information would have a greater reliability relative to information collected and presented at the same scale.

Many commentators suggest or state that scales around 1:5,000 to 1:30,000 are suitable for farm management purposes within paddock units (USDA, 1952; Cutler, 1977; Dent & Young, 1981; Robert, 1989; Hewitt & Lilburne, 2003). LR information at scales larger than 1:10,000 is regarded as being highly detailed, and therefore most suited to intensive land uses such as dairy farming and perhaps some finishing farms (particularly when irrigated). Smaller scales of around 1:25,000 are more suited to extensive agricultural uses such as hill country farming. Such scales have proven to be adequate for the provision of soil information in the United States, whereby the most of the country is represented by published soil maps at scales between 1:24,000 to 1:31,680.

4.3.1.3 Quality standards

The term *quality standards* is used here to group the various methods of measuring or estimating the quality of different types of LR information (excluding scale). These include the conventional measures of attribute variability, purity, positional accuracy, observation density, along with a less conventional estimate of scientific rigour defined by the method of information collection. These provide an indication of how reliably the real-world distribution and attributes of land resources have been abstracted and recorded as LR information.

Attribute variability is a measure of unit precision (defined as the repeatability of a measurement or observation), whereby the value of a given attribute measured at a specific site will exhibit variation when measured at other sites. *Intra-unit precision* is the variability of an attribute within a mapping unit, and *inter-unit precision* is the variability of an attribute across spatially dislocated mapping units. This is similar to the concept of *map purity* used in soil survey, defined as the percentage of unbiased check-sites at which a soil map adequately predicts a reference profile (Beckett & Burrough, 1971). The difference being an observation of profile-variability rather than measuring the variability of singular attributes.

Positional accuracy is the closeness of an abstracted or estimated value, to the actual expression of that value in the real-world. Hence, an accurate map can be used with a high degree of confidence to locate and measure landscape features without actually having to go to the location it represents. Positional accuracy is usually expressed as a distance from a known point (*e.g.* map accuracy = ±20m), or as a correlated fit or relation for lines and areas. As a general rule, landscape units with distinct boundaries can be depicted with a potentially high accuracy (*e.g.* paddocks, buildings), while units with indistinct boundaries tend to have a relatively lower potential accuracy (*e.g.* vegetation, soils, geology, slope).

Observation density is related to scale, but it can be used on its own to indicate the original level of survey intensity and investigation. It is reasonable to assume that in most cases a high level of survey intensity will result in LR information of a high quality (except when an intense survey is required for complicated landscapes and/or inexperienced surveyors). Survey intensity is measured as the rate of observations over a given survey area, and is usually expressed as observations per unit area of land (*e.g.* km^2) or map area (*e.g.* cm^2). A standard minimum rate is sometimes given as 0.25 observations per cm^2 of map (FAO, 1979), which equates to a minimum of 100 observations/km^2 for a 1:5,000 scale; 25/km^2 at a 1:10,000 scale; 6.25/km^2 at a 1:25,000; and 1 observation per km^2 at a 1:50,000 scale.

The quality of LR information will also be influenced by its degree of *scientific rigour*, as determined by the choice of method used to collect, analyse or interpret the information. An estimate of scientific rigour provides an indication of how objective or subjective the resulting information may be.

4.3.1.4 Accessibility

While public LR information may be available, it can sometimes be difficult to track down and obtain in an appropriate form, and at a reasonable cost. The information may be available in various media (*e.g.* paper, digital) and formats (*e.g.* maps, attribute data, vector data, image data, reports, extended legends, etc.) that may or may not be appropriate for farm planning. Likewise, the information may be available from one or many different sources (*e.g.* service providing agencies, libraries, regional authorities, universities, etc.), and may range in cost depending upon who maintains, updates and distributes the information.

The organisation that acts as a *steward* for LR information is responsible for specifying, monitoring and auditing how the information is managed, while the *custodian* is the organisation responsible for day-to-day management and distribution (Froude, 1999). A single organisation may be both a steward and a custodian.

4.3.2 INFORMATION RELEVANCE

The reliability of LR information can be measured or estimated independently from its use. In contrast, the *relevance* of information is wholly dependent on how it can be used. For a given purpose, different sources of information will vary in their relevance, particularly in regard to the types of land resources and attributes recorded as information. Hence, a geology database may have high relevance towards the purpose of locating a stable building site, but comparatively less relevance to the design of an effluent irrigation programme.

Relevance can be measured by applying a source of information to a purpose as a type of abstracted land evaluation (*e.g.* Forbes *et al.*, 1982). If the information can be successfully used in the land evaluation process, then it has a high relevance to the purpose of the evaluation. Alternatively, an indication of relevance can be obtained by surveying people who have used the information in the past (*e.g.* Handreck, 1978). However, both approaches are time consuming when there are many potential information sources.

Information relevance and reliability combine to define the utility or usefulness of LR information (Dent & Young, 1981, p.1). The aim of this section is to qualitatively evaluate the utility of public LR information sources for the purpose of pastoral farm planning.

4.4. RESULTS

Twelve assorted databases and map collections considered to have a potential utility towards pastoral farm planning have been identified for a more detailed evaluation using the criteria discussed above. Each is presented in template format according to the form fields given previously in Table 4.1 (although order may be adjusted to optimise layout). Key features of each information source are summed as strengths and limitations towards their potential use for pastoral farm planning purposes.

For a more complete overview of land related map collections and databases, the reader is referred to Molloy (1980), Clarke (1982), LINZ (1986), Sheerin (1992), Froude (1999), and Statistics New Zealand (www.stats.govt.nz/domino/external/web/catv2.nsf/byKeyword?openview).

4.4.1 New Zealand Land Resource Inventory (NZLRI) Worksheets

Abstract	• A series of 330 maps representing a national physical inventory of five land resources (Land Resource Inventory or LRI) together with a Land Use Capability (LUC) classification. LRI and LUC are combined within the same mapping unit. • LRI records rock type, soil unit, slope, erosion type & degree of severity, and vegetation cover. LUC derived from LRI as an 8 class general-purpose capability classification divided into 3 hierarchies: Class (general suitability for arable, pastoral and forestry land uses), Subclass (most limiting factor towards land use), and Unit (groups similar LUC classes according to management requirements). • First edition mapping between 1973 & 1979. Second edition mapping post-1979, which included a scale revision and partial updates of inventory information (for Northland, Gisborne-East Cape, Marlborough, Wellington, and part Waikato). Most recent updates not published as Worksheets but held in the NZLRI Database (Section 4.4.2). • Considerable supporting information: 12 regional LUC Extended Legends providing additional information on LRI factors, along with capability information concerning production potentials and management requirements; 8 regional bulletins detailing LRI factors according to LUC units; and well-developed methodologies & guidelines for classifying erosion, vegetation, rock-type and LUC. The soil unit can be related to other existing soil surveys for additional information. • Purpose: originally designed for regional and national land use planning, with a particular emphasis on soil conservation (see Chapter 5 for more detail on the NZLRI).
Geographical coverage	• Almost complete national coverage. Excludes Stewart Island, several other smaller islands, and urban areas.
Method of collection	• Stereographic interpretation of aerial photos to identify primary mapping units, followed by assessments of existing information and field work to differentiate units according to similarities between rock-type, soils and slope. These units are subsequently assessed to identify erosion and vegetation factors (thereby becoming complete LRI units). • LRI information evaluated against climatic and land use information to classify each LRI unit according to the LUC classification system (MoW, 1969). • Method used for deriving the soil unit has been particularly contentious (*e.g.* Cutler, 1977; Gilchrist, 1980; Cutler, 1980; Hunter, 1980; Hawley & Leamy, 1980). Where possible, existing soil information from published surveys at complementary scales was used (1:31,680; 1:50,000; 1:63,360). In the absence of such information, soil maps presented at 1:126,720 and 1:253,440 scales were used as a basis for predicting the likely occurrence of soils within LRI units. Approximately 37% of the NZLRI soil information for the North Island, and 83% for the South Island, has been derived from the 1:253,440 General Soil Survey of NZ (LINZ, 1986). While being complemented with field checks (often by students under supervision), the resulting soil information is generally regarded to be of a lower standard than that obtained through conventional soil survey for presentation at 1:50,000.
Information types	• Worksheets include their own legends describing rock type, slope, erosion type & severity, vegetation cover, and references are given to relate the soil unit to published soil surveys. • Extended Legends describe LRI and LUC in greater detail. Additional information is provided on land use, potential erosion, and recommended management. • Land Resource Inventory is descriptive (factual) information, with most factors other than erosion and vegetation having an extended temporal relevance. Land Use Capability is interpretive information, and should be updated as technology, economics and land use change (particularly in relation to overcoming resource limitations).

Scale	• Majority of maps currently in circulation presented at 1:63,360 scale on a modified NZMS 1 base map (NZ National Yard Grid). More recent updates presented at 1:50,000 on NZMS 260 base map (NZ Map Grid). • LRI/LUC units originally compiled at 1:63,360 using air photo interpretation. In part, this is due to an originally envisioned publication scale of 1:250,000 for a national map series. The decision to publish at 1:63,360 eventuated after much surveying had been completed. More recent updates are likely to have used larger scale aerial photos, as suggested by significantly smaller map units recorded in the NZLRI database (Section 4.1.2). • Smallest map unit depicted on the Worksheets is generally 15-25ha (Page, 1995; Stephens et al., 1997).
Reliability	• Positional accuracy and original observation densities are unspecified. For recent updates it is reasonable to expect that positional accuracy should correspond with the ±22m specified for the NZMS 260 base maps. • A suggested map purity for the NZLRI is often given as a 'rule of thumb' assumption. Stephens *et al.* (1997) state that users could expect that up to 15% of any given LRI unit may be poorly described, but this factor is more commonly expressed as 20% (*e.g.* Jessen *et al.*, 1999). This 'rule of thumb' has never been formally evaluated, and is perhaps overly optimistic for less obvious LRI factors such as soils. An 80-85% purity in soil survey is notoriously difficult to achieve, and it is perhaps more realistic to expect a range of 50-65% purity in real terms (Dent & Young, 1981). • Scientific rigour: Wholly empirical, including the survey method and classification according to the Land Use Capability system (MoW, 1969). This system has been well-tested and validated (see Chapter 5).
Accessibility	• Readily accessible from most libraries, universities, regional authorities, and Landcare Research (who are custodian & steward). May be purchased from Landcare Research at a cost of $25 per Worksheet. • Available as 610 x 845mm paper maps for 1:63,360 versions (land area represented ≈1320km^2 per map) and 660 x 1065mm size for 1:50,000 versions (land area represented =1200km^2 per map).
Key limitations	• A scale of 1:50,000 and minimum mapping unit of 15-25ha is too generalised for farm planning purposes. • LRI data limitations: Much of the information is out of date (particularly vegetation, erosion and production potentials); low confidence in soil information for areas not represented by existing soil surveys; assumed or unknown information quality; and the information cannot be used for specific land evaluations unless it is linked with more-detailed information from other sources. • LUC classification limitations: the classification is too general for specific applications; an emphasis on arable over other land uses; a disproportionate allocation of land into some classes (*e.g.* LUC Class V); and it is partially out of date, particularly in terms of limitation subclasses and land use. • Worksheets include a lot of detail for each polygon unit. It can sometimes be difficult to discern LRI and LUC codes for smaller polygons. Unless the user is familiar with the LRI and LUC system, then extracting information can be a time consuming exercise. An effective understanding the system requires a degree of training or experience. • Detail provided on Worksheets can rapidly become illegible under frequent in-the-field usage.

Key strengths

- Reliable & almost complete coverage.
- A number of land resources and features are recorded.
- The LUC classification is hierarchical and can therefore be used to provide three levels of detail depending on purpose.
- Affordable and accessible.
- Readily linked to other sources of information (particularly soils).
- Comprehensive supporting information.
- The LRI/LUC system is well-understood by most regional authorities.

Relevance to pastoral farming

- Not originally designed for use at farm scales. The method of environmental/conservation farm planning was developed for this purpose (Chapters 5 & 6).
- Historically used to provide a referencing standard for farm-scale LRI & LUC surveys undertaken by regional and catchment authorities for conservation/environmental farm planning.
- Traditionally used by farm consultants, fertiliser representatives and real estate agents to name the soils occurring on a given farm. Productivity information may also be used in a similar 'general overview' manner.
- May be potentially used as a starting point for more detailed farm surveys, and perhaps for the preliminary location of land with desirable attributes (*e.g.* for farm purchase). However, overall relevance to individual farms is low, primarily because of an inappropriate scale, unreliable information (at the farm level), and a lack of detailed information for specific land evaluations.

4.4.2 New Zealand Land Resource Inventory Database

Abstract

- The NZLRI Database is the digital equivalent of the NZLRI Worksheets without the topographical base maps. It is made up of a spatial database and an attribute database.
- The spatial database contains vector references for 101,572 polygon units (pre-1999 version) coordinated to the NZ Map Grid. The attribute database contains a corresponding number of records, each of which is described by approximately 30 attribute fields.
- All supporting information described for the Worksheets is relevant to information contained in the Database. The Database can be differentiated as being relatively more up to date in parts.

Geographical coverage

- Almost complete national coverage. Excludes Stewart Island, several other smaller islands, and urban areas.

Method of collection

- See NZLRI Worksheets (Section 4.4.1).
- Map unit boundaries subsequently digitised and keyed into microcomputers using specially developed programs (TRACE and POLAR). Early data management was through the Land Dependent Data (LADEDA) software, which was later replaced by the widely used Arc Info GIS and its successive variants.

Information types

- See NZLRI Worksheets (Section 4.4.1).
- Descriptive attribute fields include: LUC; rock type; soil unit; slope; erosion; vegetation; unit area (ha); radiata pine site indexes; stock carrying capacities; and soil classification. Some of these factors are broken down further (*e.g.* rock type is further separated into 'top-rock' and 'base-rock').

Scale

- Data recorded at a scale of 1:50,000.
- Smallest polygon unit is 0.02ha, and 1907 polygons are smaller than the minimal legible delineation of 10ha (for a 1:50,000 scale map). Many of these are likely to be digitising errors, although updated areas (Northland, Wellington and particularly Marlborough) exhibit a degree of consistency regarding polygons <10ha in area (Figure 4.4). The smallest readily-confirmed polygon is 3.9ha (Taupiri Island), and the largest is 611,265ha (Lake Taupo). Approximately 86% of the NZLRI's polygons have areas that range between 10-500ha (all figures calculated from a pre-1999 version of the NZLRI).

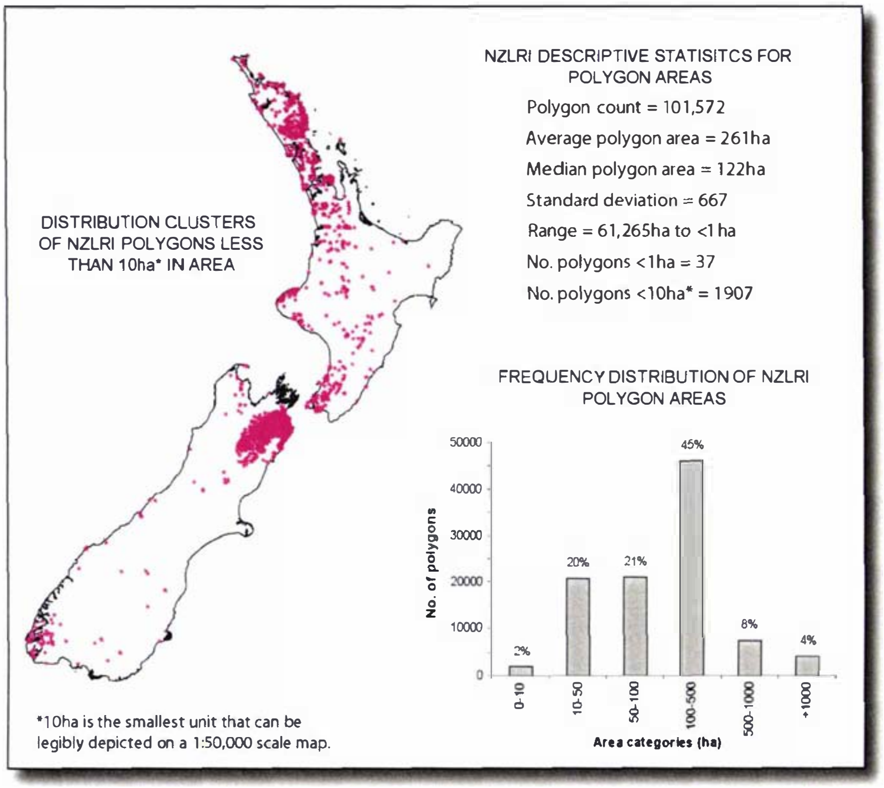

Figure 4.4: Assorted statistics for NZLRI polygon areas (pre-1999 NZLRI version).

Reliability

- See NZLRI Worksheets (Section 4.4.1).

Accessibility

- Extracts accessible from many organisations concerned with resource management (*e.g.* universities, regional authorities, Department of Conservation) and Landcare Research.
- Hardcopy output as tailored maps and tabulated summaries. This may involve a minor cost for extraction and map preparation.
- As steward and custodian, Landcare Research retails the database for academic, research and commercial purposes. However, while being a public funded information source, this can be up to $700 for 'delivery' costs even for academic purposes.

Key strengths

- See NZLRI Worksheets (Section 4.4.1).
- Relative to Worksheets, information from the NZLRI can be used to produce single factor thematic maps; overlay maps on other sources of information (*e.g.* digital orthophotos); and in being a database, the information is more-readily amendable to use in process models. The database can also be used to create tailored maps for specific locations.
- Smaller mapping units apparent with the NZLRI's most recently updated areas, would suggest parts of the database can be applied at scales slightly larger than 1:50,000.

Key limitations

- See NZLRI Worksheets (Section 4.4.1).
- Attribute information requires interpretation or referencing to other information sources.
- As a spatial database the NZLRI is scaleable. Reducing scales (*i.e.* to smaller, less detailed scales) is acceptable, but enlarging the NZLRI to scales greater than the original 1:50,000 is considered to be an unacceptable use of the information beyond its limitations (as recognised in most regional LUC bulletins, Worksheet introductions, and many other documented descriptions of the NZLRI). Such a practice exacerbates existing data errors and imperfections, thereby decreasing an already questionable reliability of the database.
- Users may not be aware of the NZLRI's existing limitations, and the magnitude to which these limitations can be worsened by enlarging information to farm scales (especially for soil information). This is evidenced by the continued use of the NZLRI at farm scales by some agricultural companies.
- Use of the database in digital form requires technical GIS skills.

Relevance to pastoral farming

- See NZLRI Worksheets (Section 4.4.1).
- Despite a greater utility over the Worksheets in terms of data manipulation and tailored map generation, information derived from the database has a similar low relevance due to limitations of scale and reliability. However, it also carries a greater risk of misuse through uninformed and inappropriate scaling of the information.

4.4.3 Catchment & Farm LRI/LUC surveys

Abstract

- Occasional catchment and district scale (*e.g.* 1:15,840 – 1:31,680) LRI/LUC surveys undertaken by catchment and regional authorities primarily for erosion and flood control purposes. Survey often preceded the application of Catchment Control Schemes (see Chapter 5).
- Targeted LRI/LUC surveys undertaken by regional authorities on individual farm units for soil conservation purposes (*i.e.* for conservation/environmental farm planning). This was either as a component of Catchment Control Schemes, or on an *ad hoc* farm-by-farm basis.
- It is uncertain if LR information collected at farm scales for conservation/environmental planning can be considered accessible to the general public.

Geographical coverage

- The exact extent of national coverage has not been documented. Individual regional authorities may be able to provide an indication of the surveys that have been undertaken within their jurisdictions.
- Sporadic and nationally uneven, being mainly concentrated into catchments and areas with a significant erosion and/or flooding risk.

Method of collection

- Mostly field-survey according to the LRI/LUC methods laid down in MoW (1969), but possibly also through aerial photo interpretation using stereographs. See Section 4.4.1.
- Many regional and catchment authorities have not used inventory survey as a basis for farm surveys, preferring the expediency afforded by directly inferring LUC in the field (see Chapter 5).

Information types	• Catchment surveys contain information similar to the NZLRI Worksheets, although earlier surveys may have used an alternative inventorying system, and classification of land capability to the class or subclass level only (see Chapter 5). • The type and comprehensiveness of information recorded in conservation/environmental farm plans varies widely between catchment and regional authorities (see Chapters 5 & 6). This can range from brief resource descriptions, through to complete farm analyses.
Scale	• Catchment surveys generally range from 1:15,840 up to 1:63,360 depending on survey extent and original resourcing. • Farm surveys range from around 1:5,000 to 1:40,000 (final presentation scale) depending on the size and area of the farm in question.
Reliability	• Largely unknown. • Often dependent on the ability of individual surveyors. Quality and content of conservation/environmental farm plans has varied over time; between different authorities; and even within authorities (see Chapters 5 & 6).
Accessibility	• Highly variable. Many early surveys have been archived or lost. Organisations most likely to hold copies include regional authorities (for surveys particular to their own regional areas), and Landcare Research (for some catchment scale surveys). • Farmers and previous farm owners/managers are likely to hold copies of farm surveys as conservation/environmental farm plans. • Catchment surveys are usually in the form of maps and reports. Farm surveys collated as part of conservation/environmental farm plans (essentially one or two maps with supporting documentation).
Key limitations	• Accessibility and (largely unknown) sporadic coverage. • Earlier surveys were not prepared according to contemporary LRI/LUC standards. • Information type, quality and comprehensiveness can vary widely. • Information users and providers not knowing if (or where) the information exists. • The type of LR information (as LRI and LUC) may not be in a form suitable for farm decision-making by the farm manager (namely the LUC classification). Such information has historically been used primarily by catchment and regional authorities for soil conservation purposes. • LRI/LUC information may be too generalised for specific land evaluations on its own.
Key strengths	• Information recorded at detailed scales suitable for farm decision-making. • A number of land resources and features are recorded. • Readily linked to other sources of LR information (particularly soils). • The LRI/LUC system is already well-understood by regional authorities, and perhaps even many farmers. • Surveys at detailed scales provide a basis for obtaining new LR information (from other existing sources, or through a new farm survey).

Relevance to pastoral farming

- Well-proven relevance for soil conservation and environmental management. Examples also exist for comprehensive land evaluations that integrate production, environmental and economic considerations. This includes the allocation of competing land uses; the design and evaluation of alternative production systems; and the protection and enhancement of areas vulnerable to degradation (Chapters 5 & 6).
- High potential for specific physical land evaluations (to replace the generality of LUC classifications), if complemented with additional information. Essentially the spatial framework is already in place, and just needs to be supplemented with specific information and measures concerning soil attributes and local climate. However, this potential is constrained to an unknown number and distribution of farms.

4.4.4 OTHER NZ LAND INVENTORY SURVEYS

Abstract

- Three individual land inventory surveys undertaken between 1965 and 1980. While being superseded by the NZLRI, the inventories tend to include a greater diversity of information types. Comprises the *Land Inventory Survey* (1965-74); *King Country Land Use Study* (1977); and the *NZ Land Inventory* (1978-80).
- **Land Inventory Survey** – County Series (NZMS 237): An inventory comprising of 'a set of maps depicting different aspects of the land and its use (land cover, soils, land tenure, land use, land slope, etc.). This is supplemented by a booklet containing information about the area covered, with details of such factors as history & development, population growth, communications, and climatic conditions' (Clarke, 1982, p.17).
- **King Country Land Use Study** (NZMS 288): A regional survey of the King Country that includes maps of rock types, soils, land tenure, vegetation, wildlife & land use, and accompanied with 'physical suitability overlays' for agriculture, indigenous forestry, exotic forestry, recreation, and conservation.
- **NZ Land Inventory** (NZMS 290): 'A map series depicting a number of physical, economic and cultural characteristics of the land as factor themes; and designed to serve as a planning tool in the land management decision-making process' (LINZ, 1986, p.160).

Method of collection

- All three inventories were compiled in an interdisciplinary manner, which in some cases involved contributions from at least 20 assorted government and local authority groups (Molloy, 1980). With the government departments, each undertook assessments and surveys according to their own discipline-particular methodologies. Interpretations were subsequently prepared collaboratively under a single coordinating and administering organisation (usually the Department of Lands & Survey).

Information types

- **Land Inventory Survey**: Descriptive information for *land cover; geological resources; soils; land use; land slope; and land use.* Interpretive information as *potential pastoral use of soils.* Unpublished information also collected for land capability, production performance, and carrying capacities (DLS, 1979). Information presented as maps, overlays and reports.
- **King Country Land Use Study**: Descriptive information for *rock types & surface deposits; soils; land tenure; forest & scrub types; wildlife; and existing land use.* Interpretive 'physical suitability overlays' for *agriculture; indigenous forestry; exotic forestry; recreation; and conservation.* Information presented as maps, overlays and reports.
- **NZ Land Inventory**: Descriptive information for *land tenure & holding; existing land use; wildlife; rock types and surface deposits; soils; and land slope.* Information mostly as maps and reports (and one overlay for land slope).

Geographical coverage

- While initially planned as national inventories, the degree of coverage attained is uneven, sporadic and incomplete (Figure 4.5).

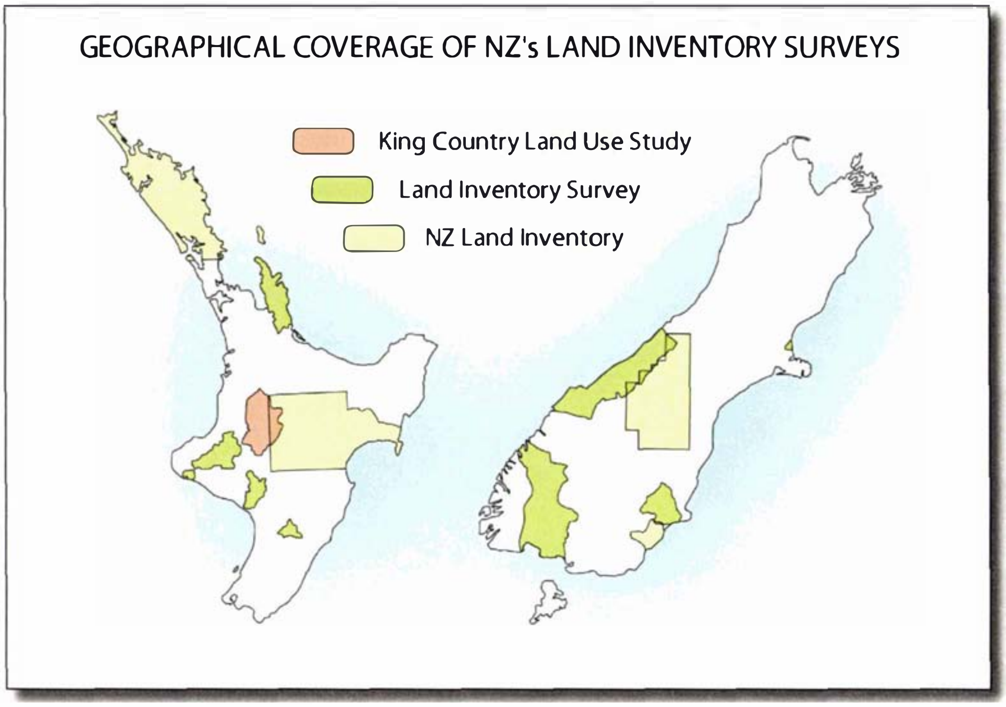

Figure 4.5: Geographical coverage of the King Country Land Use Study, the Land Inventory Survey, and the NZ Land Inventory (adapted from Clarke, 1982).

Scales

- **Land Inventory Survey**: Most maps and overlays at 1:63,360 (Minimum Legible Delineation or MLD = 16ha), but maps for 'Waimairi' published at 1:31,680 (MLD = 4ha), and maps for Westland and Coromandel-Thames published at 1:126,720 (MLD = 64ha).
- **King Country Land Use Study**: Presented at 1:63,360 (MLD = 16ha).
- **NZ Land Inventory**: Most maps at 1:100,000 (MLD = 40ha) but some at 1:50,000 (MLD = 10ha).

Reliability

- Unspecified and probably unknown. Likely to vary according to the standards maintained by the government departments responsible for collecting the information.

Accessibility

- Can be difficult to access. Many early surveys have been archived and are no longer used. Exceptions include individual inventory maps that have been subsumed into contemporary map collections (*e.g.* The NZ Soil Map Collection). Organisations most likely to hold copies include Landcare Research, universities, and possibly some libraries.
- Cost of obtaining the information would vary according to how readily it could be sourced, and by how much information would need to be copied.
- In contrast to the NZLRI, inventories are presented as single factor maps with transparent overlays. Most inventories have their own accompanying reports, although only pamphlets were prepared for the NZ Land Inventory. The King Country Land Use Study has considerable supporting information, but this can also be difficult to source.

Key limitations

- Much of the information has short temporal relevance, particularly in regard to vegetation, land use, socio-economic information, and the various land suitability maps. It is now either defunct or of historical interest only.
- The information can be difficult to source.
- Unknown or unspecified information quality.
- The types of information included are for the most part too general for specific land evaluations. However, more detailed information may have been collected but not presented in the reports (*e.g.* measures for soil attributes).
- Scales are too small and generalised for farm planning applications (1:50,000 to 1:126,720). The exception is the Waimairi Land Inventory Survey (1:31,680), which may be suitable for less intensive farming operations (MLD = 4ha).
- Geographical coverage is inconsistent, scattered, and incomplete.

Key strengths

- Many different types of land resource information are included as one inventory.

Relevance to pastoral farming

- Designed for land use planning at district and regional levels. Limited relevance for farm planning because of scale, incomplete coverage, age, and the difficulty of actually obtaining the information. Also unsuitable for specific land evaluations.
- Perhaps some value for providing a general overview of local land resources for more intensive surveys.

4.4.5 THE NEW ZEALAND SOIL MAP COLLECTION

Abstract

- A range of maps and associated documentation providing information on the distribution and attributes of NZ soils at a range of different scales.
- Includes at least 200 individual maps and 130 reports and bulletins (Sheerin, 1992). More recent catalogues record a total of 291 soil surveys completed between 1939 and the late 1990s (Clayden *et al*., 1997; Wallace *et al*., 2000). This includes various unpublished and provisional soil maps.
- The majority of NZ soil maps have been prepared by the now defunct NZ Soil Bureau. A limited range of more recent maps have also been prepared by Landcare Research.
- Many uncategorized surveys at farm scales have also been prepared by private organisations and university students. These are not included in the NZ Soil Map Collection.

Scale

- Scales range from extremely high details of 1:200 through to general purpose surveys of 1:253,440. Complete coverage of NZ has been achieved at 1:253,440 (the General Soil Survey of NZ), but this evaluation is only concerned with scales of 1:126,720 and larger. Common scales include:
  - 1:10,000 and larger.
  - 1:15,000 & 1:15,840.
  - 1:20,000 & 1:25,000.
  - 1:31,680.
  - 1:50,000 & 1:63,360.
  - 1:100,000 & 1:126,720.
- Approximately half the **number** of surveys catalogued by Clayden *et al.* (1997) and Wallace *et al.* (2000) are larger than 1:31,680 (53%).

Geographical coverage

- National coverage at 1:253,440 (the General Soil Survey of NZ).
- More detailed surveys undertaken mostly on an *ad hoc* basis since the late 1930s. Limited areas have been systematic (*e.g.* Northland), often as a part of land inventory or land-utilisation surveys. Resulting coverage has been extensive but sporadic (Figure 4.6).
- Molloy (1980) estimated 30% of NZ's land area (≈ 8 million hectares) was represented by regional & district scale soil maps (1:30,000 to 1:175,000), and 7% by detailed soil maps (*i.e.* ≈ 1.85 million hectares at scales larger than 1:30,000). Data provided by Landcare Research (Figure 4.6) suggests the coverage of regional scale maps has increased to at least 36% and perhaps even as much as 50% (the data set is not yet complete). Detailed soil maps are also likely to have increased substantially.

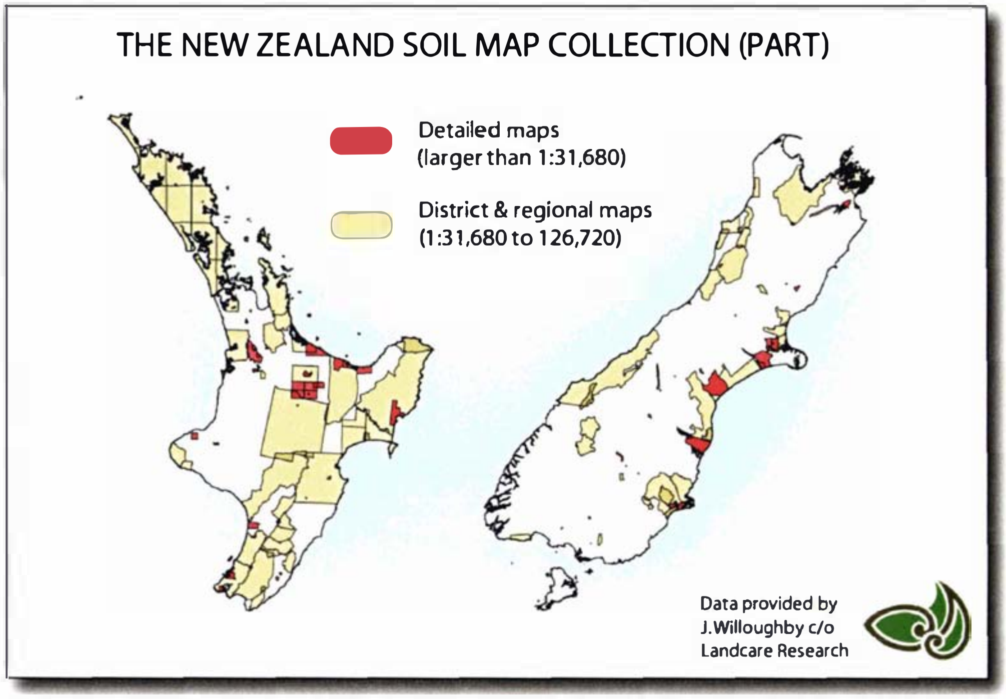

Figure 4.6: Part geographical coverage of the NZ Soil Map Collection (maps larger than 1:126,720).

Representation is incomplete (coverage database in preparation) and many maps at scales larger than 1:31,680 are too small in areal extent to be displayed.

Method of collection

- Likely to be mostly conventional 'free survey' (*cf.* grid or transect survey, etc.) according to standards and soil survey methods given by Taylor & Pohlen (1962) and Milne *et al.* (1995). Such methods are empirical, and effective applications are largely dependent on the skill and landscape-interpretation of individual surveyors.

Accessibility

- Available from libraries, universities, and some regional & local authorities. Collections from these organisations tend to include localised soil information (sometimes including obscure and difficult to source surveys). The greater collection is held and maintained by Landcare Research.
- Information is usually available as a paper map with associated documentation (reports, bulletins, memoirs, etc.).
- Landcare Research make available a large number of published surveys for purchase. However, many historical, out-of-print, or obscure surveys are not available for purchase.

Information types	• Varies according to survey, but usually includes maps showing soil distribution with accompanying legends that order soils into taxonomic or physiographic classifications. Maps at scales larger than 1:63,360 classify mapping units as either *soil series*, *soil types*, or *soil phases* (as the smallest soil mapping class). Compound soils may be expressed as *inclusions* or *associations* (Hewitt & Lilburne, 2003). • The majority of published surveys (95%) have been taxonomically classed using the old NZ Genetic Soil Classification rather than the more recent NZ Soil Classification (Froude, 1999). While the older survey classifications have for the most part been translated according to the new system (*i.e.* Clayden *et al*., 1997; Wallace *et al*., 2000), using the old maps with the new classification requires three-way cross-referencing. • Accompanying information may be included as reports or bulletins. Bulletins are the more comprehensive of the two, and provide detail on soil formation (local geology, climate, etc.); classification; detailed profile descriptions as representative or reference profiles; and often chemical and physical measures of soil attributes. • Some surveys include soil interpretations (physical land evaluations), often focusing on the potential suitability of alternative land uses (particularly pastoralism).
Reliability	• It has been standard practice in NZ soil survey to collect information at half the envisaged publication scale. However, it has not been standard practice to record observation densities or other measurements/estimates of information reliability. This is despite a known quality variation in some soil maps (attributable to the standards and abilities of different soil survey practitioners). In short, the quality and reliability of most NZ soil maps has never been evaluated, and is therefore largely unknown.
Key limitations	• Limited and sporadic coverage of soil surveys. Coverage is least extensive for detailed soil maps. • Undefined quality and reliability of maps. • Older surveys can be difficult to locate or access, and may require further work to update soil classifications to contemporary standards (which can be useful for sourcing additional information). • The Collection represents a number of different surveys undertaken and presented at non-uniform scales. Scales smaller than 1:63,360 are completely unsuitable for farm management decision-making. • The assumption of soil analogues, whereby measures of soil attributes from one site are assumed to apply equally both within a single unit, and across spatially dislocated units of the same soil (this is related to quality and reliability of information).
Key strengths	• Soil information generally has extended temporal relevance – historical soil maps can still be relevant to modern-day management. • Most surveys included in the NZ Soil Map Collection are regarded as public information, and should therefore only carry a minor (or nil) cost to obtain or view. • Soils are a farm's single-most representative land resource (Chapter 3; Section 3.2). Relative to land inventories, soil information provides a sound standalone basis upon which a land evaluation can be erected. • Taxonomic soil names at the application level are well recognised in NZ. Local 'soil type' names are often known and used to communicate between local farmers, authorities, and service providers. • Detailed information can be obtained through a soil map, either directly through an associated memoir (bulletin or report), or by using the soil classification to obtain information from other (secondary) sources. This includes data concerning specific measures of soil attributes.

Relevance to pastoral farming

- Detailed soil maps (larger than 1:31,680) have a high relevance to pastoral farming. They show the smallest units of soil classification (soil types & phases), and are usually sufficient for making reliable statements about soils at sub-paddock levels (Hewitt & Lilburne, 2003).
- While coverage of detailed soil maps is limited, those that do exist can be used as a reference for neighbouring farms undertaking new soil surveys.
- Soil maps between 1:31,680 to 1:63,360 have a moderate relevance to farm decision-making, as they can be used for displaying soils information at the farm level. However, they can only predict or suggest soils at the paddock level (Hewitt & Lilburne, 2003). Accordingly, they are more appropriately useful as a starting point for more detailed survey.
- Surveys with detailed descriptive information (*e.g.* measures of soil attributes) can be used for specific land evaluations. These can be supplemented with more-recent or relevant data, either though new measurements, or through secondary information sources (*i.e.* obtaining additional information through soil classifications).
- An overall high relevance to pastoral farm decision-making, limited primarily by a limited number of surveys undertaken at detailed scales.

4.4.6 District & Regional Soil-Climate Surveys

Abstract

- Three soil-climate project surveys have been undertaken in NZ over the past 10 years, ultimately towards the purpose of promoting district or regional development. Projects include: Topoclimate South (& Crops for Southland); growOTAGO; and the Tararua Land Use Project.
- **Topoclimate South**: A three year project collecting soil and climate information for parts of the Southland and Otago Regions. The project was unique in that it represents the first time a non-government organisation has undertaken extensive soil survey (albeit with substantial public funding). The project has been completed; information has been disseminated to 4,500 farmers; and *Crops for Southland* has been established for added-value services (including farm-scale land evaluations).
- **growOTAGO**: A three year collaborative project between NIWA, AgResearch, Landcare Research and Otago Regional Council. The aim is to produce a series of maps for the Otago Region, which depict soils and 28 climate parameters. Soil information is being obtained from previously published surveys. Maps are due for publication at the end of 2003.
- **Tararua Land Use Project**: A collaborative project between NIWA, Landcare Research, and Tararua District Council, resulting in the publication of 50 maps describing soil, climate and land use parameters for the Tararua District. Soil information derived from the NZLRI.
- Several organisations are collaboratively using similar methodologies to map crop suitability for Kaipara & Far North District Councils (Mackintosh, 2002).

Scale

- **Topoclimate South & Crops for Southland**: Information mapped-onto, and presented on 1:50,000 scale NZMS 260 topomaps.
- **growOTAGO**: Aim to have information available mostly at 1:50,000 scales.
- **Tararua Land Use Project**: Mapping units derived from the NZLRI (1:50,000) and presented at 1:250,000.

Geographical coverage

- **Topoclimate South**: A total area of 8,058 km^2 divided into 43 survey districts. Surveying undertaken mostly in Southland Region, although a small amount of land (830km^2) was also surveyed in Otago (Figure 4.7). However, coverage is somewhat incomplete, as efforts focused on land with the greatest potential for intensive uses (*e.g.* lowland, river valleys, terraces, etc.).
- **growOTAGO**: A total area of 29,000 km^2 (Figure 4.7) representing complete coverage of the Otago Region.
- **Tararua Land Use Project**: Complete District coverage of 4,800 km^2 (Figure 4.7).

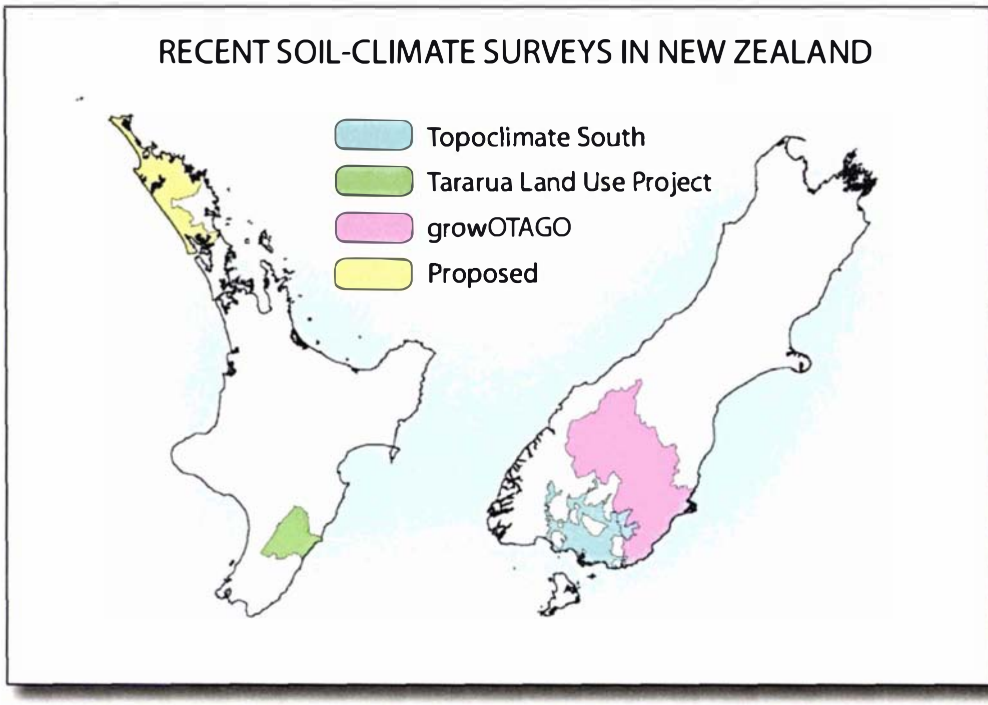

Figure 4.7: Soil-Climate surveys in New Zealand.

Method of collection

- **Topoclimate South**: 'Free survey' for mapping soil distribution; profile description of representative soils to a depth of 1m; soil measures for 12-15 attributes; soil classification according to the NZ Soil Classification; 3000 climate data-logging stations distributed across the Region (one per 200-300ha) to measure temperature for one complete year, with results correlated with records from nearby weather stations.
- **growOTAGO**: Climate information derived and interpolated from historical records, weather stations, and 12 strategically located data logging stations. Soils information taken from existing surveys (likely to be existing soil surveys at a range sub-regional scales where available, and then defaulting to soils information contained in the NZLRI where district surveys have not been undertaken).
- **Tararua Land Use Project**: Soil distribution inferred from the NZLRI. Soil attribute measures taken from the National Soils Database and other existing sources, and supplemented with new measures where necessary. Interpretive soils information produced according to methods adapted from Webb & Wilson (1995). Much of the climate information derived and interpolated from long-term records and a strategic few data logging stations.

Information types

- **Topoclimate South**: Soil and climate maps. Climate maps portray the long-term annual heat pattern in growing degree days (GDD) above a base temperature of 4^0C. Additional information collected on soil-profile morphology; water holding capacity; porosity; drainage; texture; structure; depth to parent material; stoniness; available nutrients; long-term nutrient supply capacity; soil organic matter; and soil mineralogy.
- Specialised farm maps (*e.g.* at 1:10,000) available from *Crops for Southland.* Includes Farm Climate Map & Report; Fertiliser Priority Map; Land Use Diversification Map; Growing-Degree-Days (nominated base temperatures); Crop options; Pasture options; Forestry options; Combined land use options; Sustainability; and Soil vulnerability. This service typically involves enlarging 1:50,000 scale information to farm scales, although detailed farm surveys will be undertaken for a price.
- **growOTAGO**: Soil and climate maps to be published (a total of 3000 individual maps).
- **Tararua Land Use Project**: Thirteen descriptive soil maps; five interpretive soil maps; and thirty-seven climate related maps.

Reliability

- **Topoclimate South**: The only indication of quality provided is observation density inferred from a total 47,000 soil auger and 600 soil profile examinations. This equates to 1.4 observations per square kilometre (0.06/ha), which according to the FAO, is the minimum number of observations necessary for mapping at a scale of 1:42,000. This represents an appropriate survey intensity, thereby, suggesting a confident degree of reliability at the presentation scale of 1:50,000.
- **growOTAGO**: Unspecified as of yet.
- **Tararua Land Use Project**: Unspecified. However, soils information has been inferred from a 1:50,000 scale for presentation at 1:250,000. Hence, as 1:250,000 scale maps, the information is likely to have a high degree of reliability (provided the maps are not enlarged).
- With all three soil/climate surveys, climate information has been interpolated and predicted from a limited number of sites, often for only a short period. It is therefore difficult to assign an estimate of reliability to such information.

Accessibility

- **Topoclimate South**: Many farmers have already received soil and climate maps of their own farms (approximately 4,500 farmers). The maps are readily available through *Crops for Southland*, along with a number of value-added services (farm plans, physical land evaluations, detailed soil surveys).
- **growOTAGO**: To be made available as a public resource obtainable through the Regional Council.
- **Tararua Land Use Project**: Complete collection of maps and associated reports available on CD-ROM from Tararua District Council for \$10.00. However, file sizes for individual maps range up to 20Mb, and can therefore be difficult to view on some computers. Printed maps are also available at cost, and a 'Map Book' is available at the Council for viewing. There is limited supporting information.

Key limitations

- Scale is the greatest limitation of all three soil-climate surveys. The 1:250,000 scale Tararua Land Use Project is completely unsuitable for farm management purposes. While 1:50,000 scales have greater relevance, they are still too general for farm-scale applications. Topoclimate South's practice of enlarging maps to farm scales carries a risk of lowering information quality (by exacerbating errors), and misinforming or misleading farmers when scaling limitations are not recognised or acknowledged.
- Both the Tararua Land Use Project and growOtago represent a rehash of existing soil information.
- Largely unknown reliability of all three sources of information.

Key strengths

- Climate information is included, which has value for land evaluations concerning alternative crops and land uses.
- Topoclimate South: Strong support services from *Crops for Southland* and added value services (for a price). Detailed soil attribute information available.
- The information can be considered to be up to date.
- Readily available and accessible.
- Extensive coverage for the districts and regions represented.

Relevance to pastoral farming

- **Topoclimate South**: While the 1:50,000 is too general for farm management purposes, Topoclimate South soil-climate information is being promoted and applied at farm and paddock scales. This may be inappropriate when the limitations of enlarging are not clearly acknowledged on the maps, or are not fully understood by farmers making use of the maps.
- **growOTAGO**: As with the Topoclimate South maps, information presented at scales of 1:50,000 are not suitable for farm management purposes, particularly at paddock scales. However, such information has value as a basis for more detailed surveys, and for some land evaluations at a very general level.
- **Tararua Land Use Project**: Little value due to inappropriate scale. However, it may represent a singular reference for farmers (*i.e.* a large amount of consistent information from one source) interested in undertaking a more detailed survey of their properties, or for identifying local land-characteristics of interest for farm purchase.
- Soil-climate surveys have a particular relevance for evaluating the potential of alternative crop species other than pasture. Indeed, this is often the underlying purpose of such surveys, as many of the measured soil and climate attributes tend to have a direct relation with the requirements and performance of different crops.

4.4.7 THE NATIONAL SOILS DATABASE

Abstract

- A national archive of attribute measures and observations about well-characterised soils taken from specific sites. Described by Froude (1999) as a collection of soil profiles, site descriptions, and chemical, physical and mineralogical characteristics for [a significant proportion of] NZ's representative soils.
- Approximately 3000 soils are represented, half of which are represented by records held in a card filing system (mostly 1938 to 1964 records), with the other half captured in a digital database (mostly 1964 to 1993 records). Around 190 of a possible 250 NZ Soil Classification subgroups are represented.

Method of collection

- The majority of data was collected and generated by the now defunct Soil Bureau. Methods of collection and observation undertaken according to recognised standards for soil description and laboratory analysis.

Reliability

- In being point-source data obtained through mostly analytical procedures, the data can be considered to be highly reliable for measures that exhibit limited temporal variation.
- Spatial variability becomes important when the data are interpolated or extrapolated across areas via soil classification. No estimates of attribute variability are included in the database.

Geographical coverage

- Information recorded on a national basis, but the coverage is sporadic, uneven, and tends to be concentrated and clustered into areas of pastoral and intensive land use (Figure 4.8).

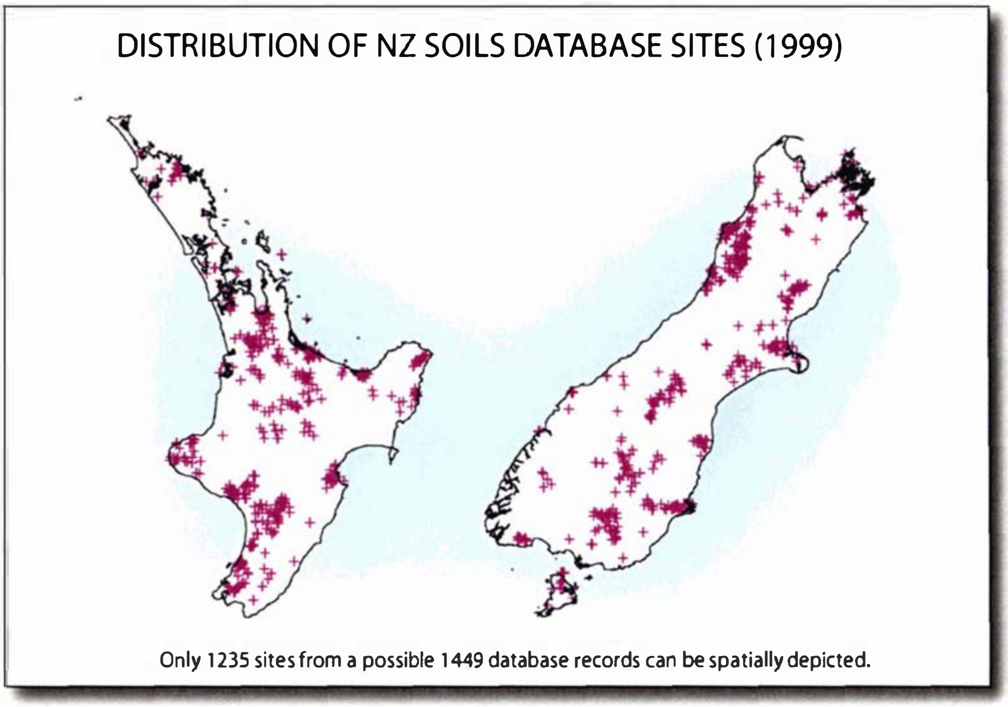

Figure 4.8: Location of National Soils Database sites for 1235 records (85% of total records) with geographical references (1999 version).

Information types

- Post-1964 data recorded as ten Paradox tables. Combined, up to 550 attributes may be recorded for some soils, but this is far from being the norm. Many records include only limited attribute information, often without even fundamental physical and chemical measures.
- A well-described soil record includes: profile morphology by horizon; site description (including climate, topography, & vegetation); particle size distribution by horizon; mineralogy by horizon; water retention by horizon; soil/void relations; and chemical and physical measures by horizon.

Scale

- Not applicable. Point-source data only.

Accessibility

- Database maintained by Landcare Research (custodian & steward).
- Complete database available for academic purposes, but this carries a 'delivery' charge. Computer generated reports available for individual soils at a cost.
- A Windows based software interface for accessing the data via personal computer has been developed by Landcare Research (known as DIGS – Data Integration and Generation for Soils).
- Generally available from Landcare Research and other organisations (*e.g.* universities) who have acquired the database.
- Limited supporting information available (*NZSB Laboratory Report SS4* & the *Soil Database Manual*). Use of the data requires a fundamental and technical understanding of soil science principles.

Key limitations

- The database does not represent all of NZ's main soils (*i.e.* subgroups).
- New records are added infrequently, often without the standard of detail afforded through comprehensive soil analysis. Addition of a new soil record could cost more than $10,000 per profile (Froude, 1999).
- Point-source data only. Requires linking to spatial soil information before the data becomes useful for application. Resulting interpolation or extrapolation of the data across areas makes information reliability difficult to estimate (*i.e.* no indication of temporal or spatial variability).
- Data requires interpretation and application before becoming useful. This requires a technical understanding of the data.
- Many database records are incomplete, and often lack even fundamental measures on physical and chemical attributes.
- Some attributes are dynamically related to land use, and may therefore be non-representative or dated (*e.g.* soil fertility measures, physical attributes of topsoil).
- Choice of site locations may not be representative. As an example, the most complete record for Dannevirke Silt Loam has been taken from Eketahuna, rather than from the immediate area in which the soil was first described (Dannevirke).

Key strengths

- Very detailed descriptive information suitable for undertaking a wide range of specific land evaluations.
- Highly reliable as point-source data (for attributes that exhibit limited temporal variation).

Relevance to pastoral farming

- Limited relevance overall, due to uneven representation of NZ soils, and the unlikelihood of being able to confidently and precisely correlate a given farm's soils with those recorded in the database.
- When used together with the NZ Soil Map Collection, the database may be useful for gaining a broad indication and perspective of a given farm's soil attributes (*i.e./e.g.* as a baseline for comparison, or as an additional tool for confirming soil classification).
- For any farmer able to confidently correlate their farms' soils with database records (higher potential for those in intensive land use areas), then the database can be an invaluable tool for specific land evaluations.
- As the database contains technical data, its relevance to pastoral farming can only usually be expressed through consultants, technicians, experts, and others with a fundamental grounding in soil science.

4.4.8 The Soil Fundamental Data Layers

Abstract

- The *Soil Fundamental Data Layers* (FDLs) represents an evolution of database refinement and integration. This began with the *Land Evaluation Database*, which summarised the somewhat unwieldy number of attribute fields available in the *National Soils Database*, to 24 'key attribute fields' considered to have the greatest relevance to the use of land. This was followed by the *NZ Soils Spatial Database*, which linked point-source records to the spatial component of the NZLRI, and limited the 'key attribute fields' to 17. This was later refined to 16 attributes, and today the database is marketed as the FDLs.

Geographical coverage	• Coverage of the North and South Islands (*i.e.* the same as the NZLRI database).
Method of collection	• Genetic soil classifications recorded in the NZLRI were correlated to the NZ Soil Classification to the forth category (the 'soil form') to provide a basis for linking point-source data to NZLRI polygons. Site, physical and chemical attributes were assigned to each of the updated classifications, using data derived from the National Soils Database and other sources. The 16 'key attributes' were selected through consultation with likely users of the information.
Information types	• Sixteen key soil attributes are recorded in the database as descriptive measures (*i.e.* ordinal rather than nominal). • Attributes include slope angle; potential rooting depth; topsoil gravel content; rock outcrops and surface boulders; depth to a slowly permeable horizon; minimum pH (0-0.6m depth); maximum salinity (0-0.6m depth); drainage class; cation exchange capacity (0-0.6m depth); total carbon (0-0.2m depth); phosphate retention (0-0.2m depth); flood return interval; soil temperature regime (0.3m depth); profile available water; profile readily available water; macropores (0-0.6m); macropores (0.6-0.9m). • As numerical measures, records in the FDLs are particularly amendable to use in process models.
Scale	• Same as the 1:50,000 scale of the NZLRI.
Reliability	• The reliability of the FDLs data is highly questionable because of the manner in which it was derived. Firstly, it is dependent on the original quality and scale of the soil information used to predict the soil unit of the NZLRI. Secondly, there is a degree of reliability or confidence lost by correlating soils from one taxonomy to another taxonomy. Thirdly, the FDLs relies on the longstanding assumption that point-source soils data can be extrapolated within a single soil polygon, and across spatially dislocated soil units. • In short, the point-source data may be reliable in a site specific manner, but when it is extrapolated through the FDLs it inherits a number of reliability limitations associated with the NZLRI, soil survey, and soil classification. There are no quality checks associated with the database (for soil purity, attribute variability, etc.).
Accessibility	• Available from Landcare Research (custodian & steward) for academic and commercial purposes. • Available as a spatial database. Requires appropriate GIS software, skills, and a grounding in soil science for application. Landcare may produce localised thematic maps of individual attributes on request, and are capable of undertaking physical land evaluations using FDLs data.
Key limitations	• The 1:50,000 scale is unsuitable for farm management purposes. • Questionable reliability arising from limitations inherited from the NZLRI; problems associated with reinterpretation of a dated soil classification; and the historical assumption of soil analogues as a means of extrapolating point-source measures of soil attributes. • The information is essentially basic data that requires specialist skills for interpretation and application.

Key strengths

- Very detailed descriptive information suitable for undertaking a wide range of specific land evaluations.
- Represents a consistent and complete data source with extensive coverage.

Relevance to pastoral farming

- Limited relevance due to scale, questionable reliability, and a need for interpretation by a service provider before application.
- In the absence of attribute data at farm and paddock scales, the FSLs may be used for land evaluations at a general or preliminary level.
- As with the National Soils Database, confidence in using the FSLs for this purpose is increased when a quality soil classification is prepared at a scale appropriate for farm management.

4.4.9 The Land Cover Database

Abstract

- The Land Cover Database (LCDB) is a digital vector-based record of NZ land cover derived from satellite imagery.
- LCDB 1 derived from 1996/97 satellite imagery and was fully completed in 2000. LCDB 2 is currently being prepared (2000/2001 imagery), and aims to attain a higher degree of quality than LCDB 1.

Geographical coverage

- Complete national coverage.

Method of collection

- Compiled primarily from satellite imagery on a five-yearly basis. Imagery is orthorectified using a digital elevation model derived from 20m contours (LCDB 1). Eighteen land cover classes erected, and manually digitised on-screen as vector polygons. Classification is assisted through the ancillary use of aerial photography, topographic information, and forestry maps. Predicted land covers were ground-truthed and an accuracy assessment undertaken. LCDB 2 has been upgraded to 61 land cover classes.

Information types

- Land cover classes include: urban; mines & dumps; urban open space; bare ground; coastal sand; inland water; wetland (inland & coastal); horticultural; pastoral; tussock; scrub; mangroves; major shelterbelts; planted forest; and indigenous forest.

Scale

- Satellite imagery used to derive LCDB 1 had a 20m spatial resolution (one pixel is the ground equivalent of 20m x 20m or 400m^2). However, the Minimum Mapping Unit (MMU) for the polygons was set at 1ha. If presented on a paper map, a MMU of 1ha equates to a scale of 1:15,800 (using a minimal legible delineation of 0.4cm^2).
- The LCDB 2 is being prepared from 15m resolution imagery, but will retain the 1ha MMU.

Reliability

- A targeted positional accuracy of ±22m (to align with standards for topographical data).
- An overall 'classification accuracy' (*sic*) of 94% derived by truthing 17,000 points across the country. 'Classification precision' (or purity) may be a more appropriate term when such a method is used.

Accessibility	• The Ministry for the Environment are stewards of the database, and Terralink are custodians. • As custodians, Terralink distribute the information at $600 for the entire dataset, and $350 for regional datasets. This is despite being information generated by public funds for the public good. • Most regional authorities, and many universities, have acquired the database. • The LCDB 1 is generally available as a digital database, but locale-specific maps may be generated and printed on request (for a price).
Key limitations	• A MMU of 1ha is too large for most farm management purposes concerning land covers. Such a size would not provide a farmer with any additional information he or she did not already know.
Key strengths	• Consistent nationwide coverage. • Regular five-yearly updates. Represents recent and up-to-date information. • A reasonably high degree of information quality and reliability.
Relevance to pastoral farming	• Limited relevance to pastoral farming despite a suggested detailed scale of 1:15,800. It is likely farmers are well aware of land covers greater than 1ha as they occur on their own properties. Vegetation covers at highly detailed scales (*e.g.* for the distribution & cumulative area of shrubby weeds, erosion control plantings, etc.) is one example of management units that exist well below the paddock scale.

4.4.10 LAND ENVIRONMENTS NEW ZEALAND (LENZ)

Abstract	• LENZ is a database containing 15 descriptive layers (seven for climate, one for landforms, and seven for soils), and a quantitatively derived classification of land environments. Underlying data has been sourced from other databases (quantitative & qualitative data), and the 4-tier classification is based on ecological principles (particularly as they relate to the occurrence of indigenous tree species). • The main purpose of LENZ is to provide a nationally consistent classification for conservation and resource management, but it is also considered relevant to agriculture and forestry endeavours. • Underlying classification concepts were developed in the early 1980s (as environmental domains, districts and regions). Development of the database began in 1998 (as part of the environmental indicators programme), and it has only recently been made available to the public (2003).
Geographical coverage	• Complete national coverage.
Scale	• Recommended application scales are given by Leathwick *et al.* (2003). They include 1:2,000,000 (Level 1), 1:1,000,000 (Level 2); 1:250,000 (Level 3); and 1:50,000 for Level 4 environments.

Method of collection

- The fifteen data layers are derived from existing databases and datasets (including the NZLRI). A computer process model was used to classify land environments.

Information types

- Fifteen GIS data layers for: annual temperature; winter minimum temperature; annual solar radiation; winter solar radiation; annual water deficit; monthly water balance; October vapour pressure deficit; slope; soil drainage; soil P; soil calcium; rock hardness; soil particle size; soil age; and chemical limitations to plant growth.
- A four-tier hierarchical classification of land environments for presentation at different scales. Includes: Level 1 (20 land environments); Level 2 (100 land environments); Level 3 (200 land environments); and Level 4 (500 land environments). Level I environments presented in Figure 4.9.

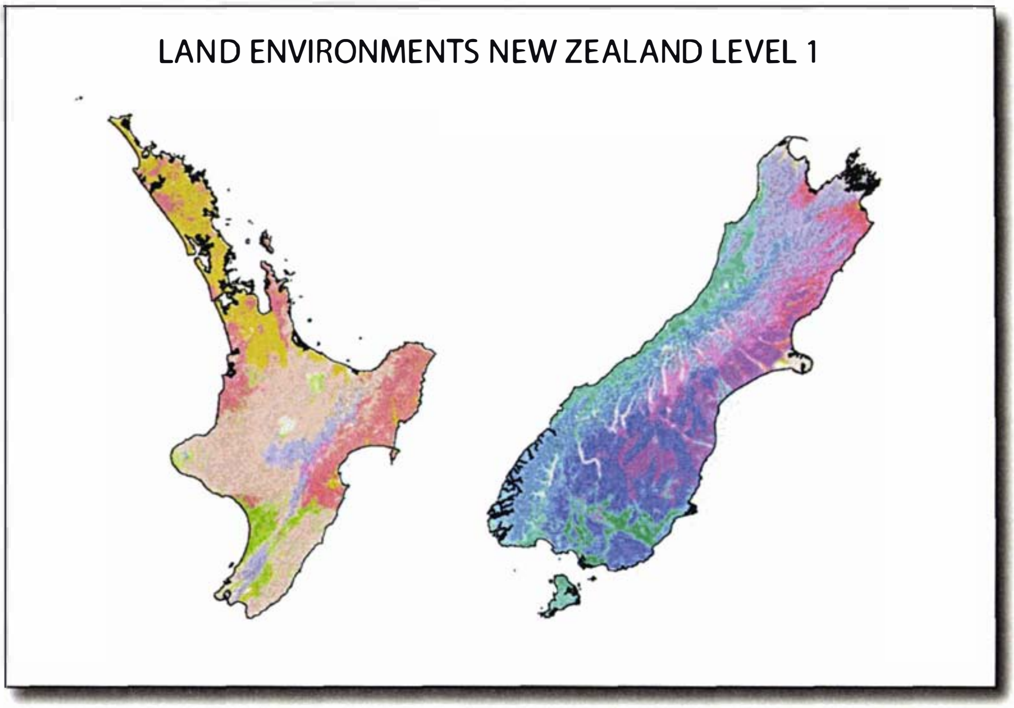

Figure 4.9: LENZ Level 1 (20 land environments).

Reliability

- Data layers stored digitally as images (GRID format). The smallest resolution of a single image pixel equates to 25m. Slope derived from 20m contours.
- Reliability and quality of LENZ is dependent firstly on the underlying data, and secondly on the robustness of the process model used to classify land environments. No comment is made about the model, but in being derived from other national datasets, the underlying data comes with many reliability limitations associated with interpolation, extrapolation, the assumption of land analogues, along with problems previously discussed for the NZLRI.

Accessibility

- The Ministry for the Environment are stewards of the database, and Landcare Research are custodians.
- Available as a hardcopy atlas for general use (*i.e.* Leathwick *et al*., 2003), and as a twin set of CD-Roms (one containing classification layers, and the other containing the 15 datasets). The atlas costs $50.00, and the set of CD-Roms cost $700.00 (despite being publicly funded and owned). A free technical guide is also available.
- Extracts possibly available from regional authorities, Landcare Research, and universities.

Key limitations

- Often presented with considerable visual appeal (*e.g.* as coloured thematics draped over a DEM and presented from oblique perspectives). Users should be aware this is mostly visual impact, and should be more concerned with the technical soundness of the underlying data and process model.

Figure 4.10: Example of the visual impact from a LENZ extract.

- LENZ inherits limitations from other databases and datasets (*e.g.* the NZLRI).
- As a process model, the resulting classification is rigidly based on only a small number of variables (relative to those apparent in the real world).
- While using a quantitative model for classifications, some of the underlying data is qualitative (*e.g.* soil information derived from conventional survey and classification).
- A suggested scale of 1:50,000 (Level 4 environments) is too general for farm management purposes.

Key strengths

- Integrates a number of land datasets as one package.
- Automated and quantitative process model.
- While the primary classification is ecologically based, other 'process model' classifications can be erected (*i.e.* as physical land evaluations). Leathwick *et al.* (2003) provide an example for identifying areas in NZ suitable for specific types of viticulture.

Relevance to pastoral farming

- Despite considerable hype about LENZ, the database is not as impressive as some make out. While the process model is certainly innovative, it is just another method of classifying land (*i.e.* physical land evaluation). The greater utility and versatility of the database is in the underlying data, but this is more-or-less a rehash of existing datasets.
- The classification has little immediate relevance to pastoral farming. However, the underlying data is amendable to use for agricultural land evaluations (*e.g.* classifications of crop suitability) through alternative process models.
- An overall low relevance to pastoral farm management due to limitations of scale, a small number of recorded attributes, and limitations common to – or inherited from - other datasets (see NZLRI and the Fundamental Soil Layers).

4.4.11 TOPOGRAPHICAL MAPS & DATABASES

Abstract

- Maps and digital data that (generally) describe the location and pattern of relief, utilities, transport, geographic features, physical structures, surface water, and various land covers (*e.g.* vegetation). A range of topographic maps and databases exist:
- **NZMS 1**: Former '1 inch to the mile' map series (1:63,360) based on the NZ National Yard Grid. Superseded by NZMS 260.
- **NZMS 270**: Topoplot series of composite transparencies presented at 1:25,000. Each set includes a sheet showing 20m contours, and another 'detail sheet' depicting land covers and physical resources (roads, fences, structures, etc.). This topoplot series was used to derive the NZMS 260.
- **NZMS 260**: Topographical map series (300 maps) based on the NZ National Grid (metric). Widely used, and available as paper maps, digital image maps, and as vector data (topodata).
- **Project topographical maps**: A large number of highly variable topographical maps designed specifically for individual clients.

Geographical coverage

- Complete national coverage for NZ Map Series 1, 260 and 270. Sporadic coverage of project topographical maps.

Method of collection

- Mostly planemetric survey for older map series, and photogrammetry for the more recent (essentially interpreting and digitising landscape features from photography). Land Information NZ (LINZ) is currently updating the NZMS 260 through the interpretation of 1:25,000 scale orthophotographs.

Information types

- Topographical maps usually depict: contours and spot heights; vegetation covers; physical features (*e.g.* structures, utilities, fencelines); surface hydrology (*e.g.* rivers, lakes, wetlands); and some landscape features (*e.g.* bluffs).
- Most topographical information available as paper maps. NZMS 260 is also available as digital image maps, and the underlying data is readily available in vector formats. Graphically interactive evaluation of vector data is now available through a number of websites (*e.g.* www.geographynetwork.co.nz or www.massey.landcare.cri.nz).

Scale

- 1:63,360 for NZMS 1.
- 1:25,000 for NZMS 270.
- 1:50,000 for NZMS 260.
- Scales ranging between 1:100 and 1:50,000 for project topographical maps.

Reliability

- Strict positional accuracy standards for NZMS 260 of ±22m horizontally (*i.e.* a point may vary in any horizontal direction by 20m), ±5m vertically for points, and ±10m vertically for contours. These are high standards for a 1:50,000 scale map, due to a necessary compromise between legibility and real-world representation. As an example, the line width used to legibly depict road widths on a NZMS 260 equates to approximately 40m on the ground. Likewise, a single ink dot may represent 200m^2 (≈14m x 14m).
- Topographical surveys generally attain a high positional accuracy (relative to their final presentation scale) because of quantitative survey methods, and the distinctiveness of feature boundaries.

Accessibility	• Readily available from numerous sources, particularly in regard to NZMS 260. Sources include libraries, universities and map retailers. • Land Information New Zealand is custodian and steward for topographical information and data. However, distribution is most often through secondary agencies.
Key limitations	• Limited availability and coverage of detailed topographical maps. • High cost of undertaking detailed surveys in the preparation of topographical maps at scales suitable for farm management decision-making. • Physical structures and vegetative land-covers an change over short periods. While contour information has extended temporal relevance, other recorded features may cause a topographical map to become rapidly dated.
Key strengths	• Topographical maps often attain a high degree of positional accuracy (relative to presentation scale). They can therefore be used reliably for calculating distances, heights and areas. • NZMS 260 maps are affordable, and readily obtainable in a number of different formats and media.
Relevance to pastoral farming	• Contours from the NZMS 270 (20m contours) have been used to construct Digital Elevation Models useful for ortho-correcting farm scale aerial photography (a high level of contour detail is not required for orthorectification). • It is feasible to suggest that a detailed topographical map represents a record of a farm's topography, physical structures and land covers. Likewise, it may also be considered as a planning tool, particularly for designing paddock layouts and water reticulation systems in hill country. However, the author has experienced a farmer ignoring a 1:5,000 scale topographical map (5m contours; professionally prepared for recreational orienteering) when designing a water reticulation system, preferring to pay for a new (purpose specific) survey to obtain height information. Such surveys are commonplace in NZ farming (when highly detailed height & distance is required for specific purposes). • An overall limited relevance for the purpose of farm management decision-making. Aerial photos provide better land cover information, and farmers may perhaps be more inclined to obtain highly accurate height & distance information through contracted survey for specific purposes.

4.4.12 GEOLOGY MAPS & DATABASES

Abstract	• A range of maps depicting New Zealand geology – rock stratigraphy, lithology, fault lines, geological formations, etc. • The existing map collection is currently being digitised, integrated and updated as the QMAP programme (for publication at 1:250,000).
Scale	• Many different scales: national coverage at 1:250,00; district and regional scales of 1:50,000 and 1:63,360; and occasional large scale surveys at 1:25,000 to 15,840 (*e.g.* for engineering purposes).

Geographical coverage

- National coverage at 1:250,000 (paper maps). Sporadic and uneven coverage at larger scales.
- Approximately 42% of NZ's land area is now represented by published QMAPs at a 1:250,000 scale (Figure 4.11).

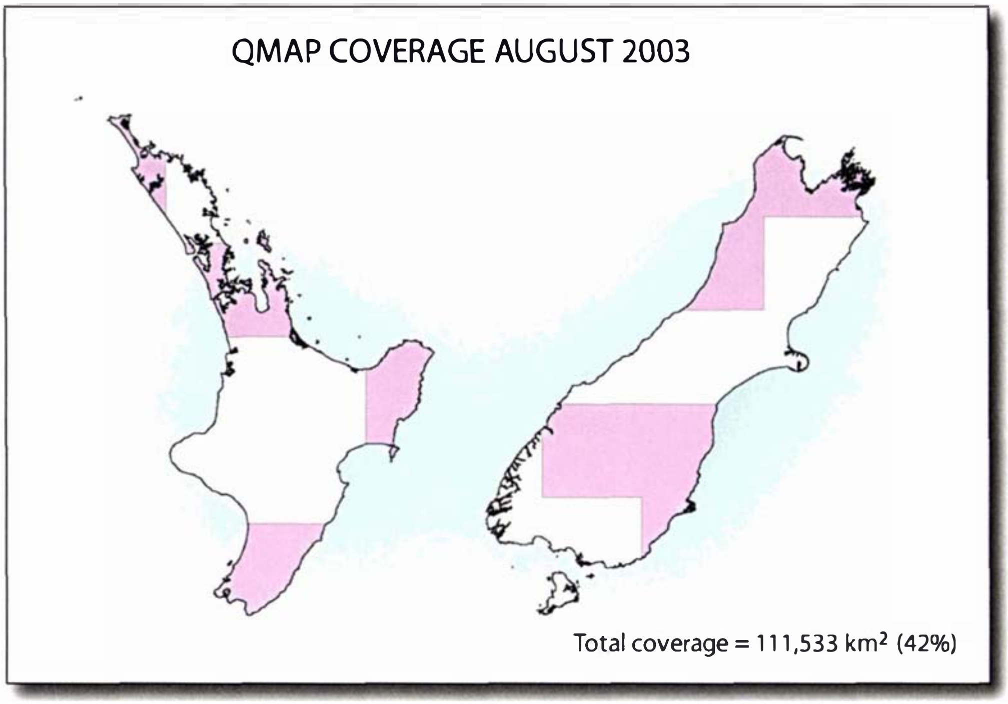

Figure 4.11: Progress of the QMAP programme as of August 2003.

Information types

- Usually include descriptive information on associated landforms, geological attributes (*e.g.* rock texture, tilt/dip, hardness, colour, strata, coherence, etc.), and geological age.
- May include analyses for engineering and other purposes.

Method of collection

- Mostly geological field survey according to standards.

Reliability

- Reliability varies according to original survey standards. Largely unknown in most cases.
- Froude (1999) provides positional accuracy estimates of ±250m for 1:250,000 scale maps, and ±50m for 1:50,000 scale maps.

Key limitations

- Traditional geology taxonomies are based on geological age rather than attributes that have a direct bearing on land use. This contrasts against the rock-type classification used in the NZLRI, which is designed and applied explicitly with land use as a consideration.
- Traditional geology maps don't usually include thin soil-forming cover deposits such as alluvium, tephra or loess. Special geology maps are used for this purpose.
- Maps and classifications may require technical or specialist interpretation before becoming useful.
- Inappropriate scales for farm management purposes, or unavailability of detailed maps.

Key strengths

Affordable and easy to obtain.

Accessibility	• Available from libraries, universities, and regional authorities. Many published maps available for purchase. • The Institute of Nuclear and Geological Sciences is custodian and steward. • Generally available as maps with reports. The QMAP programme is generating digital data versions for use in GISs.
Relevance to pastoral farming	• Relative to soils, major geological formations tend to be more consistent over greater distances (less spatial variability). This increases the relative probability of being able to correlate a farm's geology to that of district scale geology maps (*e.g.* 1:50,000). Hence, such maps have value for guiding more detailed surveys. • If the user has the ability to interpret geology maps and classifications, then they can be useful for gaining an insight into landscape evolution (important for soil survey). Likewise, when geology is considered against other land resources and features, they can be used to explain some land attributes (*e.g.* geology influences erosion, soil fertility, soil drainage, etc.). • Provided maps are sufficiently detailed and reliable, they may be used as a basis for locating suitable areas for building new structures (*e.g.* stable, away from fault lines). Maps may also be used to help locate groundwater resources. However, the opportunities for applying geological information to farm management and planning purposes is rather limited. • An overall limited value due to scale, method of classification, reliability, and few opportunities for meaningful application (other than the location of building sites and groundwater resources).

4.5. SUMMARY AND DISCUSSION

This section reviews NZ's published and readily obtainable LR information in terms of reliability and relevance towards farm management decision-making. Numerous databases and map collections exist, but only 12 were considered suitable for a detailed evaluation using predefined criteria. Despite being a general and qualitative evaluation (summarised as Table 4.2, overleaf), there appears to be a number of consistent trends and features exhibited by these information sources.

Geographical coverage is extensive for many information sources at district and regional scales (*e.g.* the NZLRI, Soil Fundamental Data Layers, Land Cover Database, Land Environments New Zealand, and topographical maps) but rather limited and sporadic for information at detailed scales. The most consistent coverages are achieved at a 1:50,000 scale, which is too broad for most farm management purposes.

A lack of soil information at district scales appears to have resulted in a default reliance on the NZLRI (and its hybrids) as NZ's premier source of spatial soils information. This is a concern, as the NZLRI was never intended as a soil map (Hawley & Leamy, 1980), primarily because of the manner in which the soil component of the Inventory was derived. This limitation is transferred when NZLRI soil information is used in other datasets (*e.g.* Land Environments NZ), and exacerbated when enlarged to farm management scales.

LR information collected and presented at scales suitable for farm management decision-making is mostly confined to occasional soil, LRI/LUC, and perhaps some topographical surveys. However, the geographical coverage of such information is scarce and sporadic.

Table 4.2: Suitability of LR information databases & collections for farm management decision-making.

	Coverage	Information	Scale Appropriateness	Reliability	Accessibility	Key Strengths	Key Limitations	Overall Relevance
NZLRI Worksheets	North & South Islands	Information on a number of resources but little on resource attributes. Some land use information.	Insufficient detail for farm management purposes.	Largely unknown or assumed. Claimed purity of 80-85%. Probably low.	High	Coverage; accessibility; a number of resources recorded; supporting information; understandable.	Scale; problems with data quality & reliability; generalised classification.	Low to moderate
NZLRI Database	North & South Islands	Information on a number of resources but little on resource attributes. Some land use information.	Insufficient detail for farm management purposes.	Largely unknown or assumed. Claimed purity of 80-85%. Probably low.	Moderate	Coverage; accessibility; a number of resources recorded; supporting information; digital manipulation.	Scale; problems with data quality & reliability; generalised classification; data in a form that requires referencing or technical interpretation.	Low to moderate
Catchment & Farm LRI/LUC Surveys	Sporadic, incomplete, & partly unknown	Varies, but generally information on a number of resources but little on resource attributes. Some land use information.	Sufficiently detailed for farm management purposes.	Mostly unknown.	Varies	Scale; often farm-particular; understandable; a number of resources recorded.	Limited coverage; information in a form that may not be suitable for multiple farm management purposes; generalised information.	High
Other Land Inventories	Sporadic & incomplete	Information on numerous resources and attributes.	Generally insufficient for farm management purposes.	Unknown but likely to be low.	Low	Variety of information on land resources and land use.	Scale; limited coverage; dated information; accessibility.	Low
NZ Soil Map Collection	Sporadic & incomplete	Generally soil distribution, classification, & profile description. May include analytical attribute information & land use information.	Varies widely. Some surveys sufficiently detailed.	Unknown	Varies. Possibly moderate overall	Information of high relevance to pastoral farming; readily linked to additional information sources.	Limited & sporadic coverage of detailed surveys; unknown reliability; accessibility in some cases; the assumption of soil analogues.	Varies according to scale
Soil-Climate Surveys	Region & district particular	Descriptive information on climate & soil attributes. Interpretive information on crop suitabilities & land use.	Insufficient detail for farm management purposes.	Mostly unknown.	High	Inclusion of climate information; good support services; contemporary information; accessibility; extensive coverage for regions/districts represented.	Scale; mostly unknown information reliability; localised coverage.	Low to moderate
The National Soils Database	N/A	Detailed & analytical point-source information for a number of soil attributes.	N/A	Very high for sites. Unknown when extrapolated via soil classification.	Low to moderate	Very detailed information suitable for specific land evaluations; high reliability as point-source information.	Incomplete representation of NZ soils; expensive to update; point-source data only; requires technical skills for application.	Low to moderate
The Soil Fundamental Data Layers	North & South Islands	Detailed & analytical point-source information for 16 soil attributes.	Insufficient detail for farm management purposes.	Unknown but likely to be low.	Moderate	Very detailed information suitable for specific land evaluations; consistent & complete dataset.	Scale; questionable reliability; requires technical skills for application.	Low to moderate
The Land Cover Database	Complete national coverage	Land cover classes.	Insufficient detail for farm management purposes.	High	Moderate	Coverage; contemporary information updated regularly; high information quality & reliability.	Scale.	Low to moderate
Land Environments NZ	Complete national coverage	15 data/descriptive layers (soil, landform & climate) and a 4 tier classification of land environments.	Insufficient detail for farm management purposes.	Unknown. Reliability of different datasets will vary.	Moderate	Coverage; integrates a number of data sources as one package; quantitative classification; suitable for specific land evaluations.	Scale; reliability limitations inherited from other datasets; largely irrelevant classification (to farming).	Low to moderate
Topographical Maps & Databases	Complete national coverage	Physical features, land cover, and height information.	Varies. Most readily available maps have insufficient detail for farm management purposes.	Generally high relative to presentation scale.	High	High positional accuracy; accessibility.	Scale; coverage of detailed scales; temporal relevance of land covers and physical structures; limited application in farm management.	Low
Geology Maps & Databases	Sporadic & incomplete	Distribution & attributes of rocks.	Generally insufficient detail for farm management purposes.	Unknown	Moderate	Affordable & easy to obtain.	Scientific classifications; limited information on soil-forming geology; scales; may require technical skills for application & interpretation.	Low

Accessibility is generally high for most information sources. The exceptions being historical surveys that are not widely known (*e.g.* localised soil & LRI/LUC surveys), or surveys that have been superseded (*e.g.* older land inventory surveys). Paper maps appear to be most accessible, as digital databases require a cost for extracting and interpreting data. Likewise, database information is often abbreviated or scientific, thereby requiring a technical background for application.

While not necessarily being relevant to farmers, most of the digital databases are expensive to obtain despite being public information sources (information collected and maintained by public money for public purposes). This ranges from $350 to $700 for public-good purposes, and is justified as a 'delivery cost'. This would be exorbitant if it simply involves dumping data onto one or two CDs and posting it to the recipient. Pricing is even higher for commercial purposes.

Another concern is the reliability of NZ's public LR information. Only two sources can validly claim high quality standards (NZMS 260 topographical maps and the Land Cover Database), as the others have not included, or not reported, a programme of quality control. This is despite the ease with which positional accuracy and purity tests can be undertaken (although historical surveys can perhaps be excused because of technical limitations in the attainment and assessment of accuracy).

Information types vary with the land resources a given source of information represents. Most include spatial information (the National Soils Database being the exception), with links to attribute information. Older surveys tend to have generalised attribute data gained through empirical methods (which can be linked to supporting or additional information that may provide quantified attribute measures), while more contemporary databases contain quantitative attribute data. In most cases this has been extrapolated or interpolated from point-source information, and therefore has a reliability dependent on land-unit classifications and taxonomies (often without any estimate of reliability as attribute variation or unit purity). Information sources with generalised, mostly qualitative data are suitable only for general land evaluations, while those with quantitative data are suitable for specific land evaluations (but are limited by the assumption of analogues when the information has been derived from point source information). The limited range of soil-climate surveys recently undertaken in NZ are highly relevant for evaluating suitabilities or versatilities of different crops.

The overall relevance of NZ's published and readily obtainable LR information to farm management is low. The principal limitation appears to one of scale and coverage, meaning that it would be likely that a farmer wanting to obtain useful LR information for his/her property, would be unable to do so because the required information does not exist. The exception would be if the farmer was lucky enough to be in an area that has been surveyed at a detailed scale (*i.e.* detailed soil or LRI/LUC survey). Other common limitations include a unknown reliability of certain LR information, and the technical character of some information sources.

It is unlikely that the coverage and detail of public LR information will increase in the near future, unless the government makes a substantial investment in new surveys, or new technology emerges to enable the efficient collection of information at detailed scales. As neither is likely, a farmer interested in using LR information in farm management and planning, must in someway collect new information at a scale and quality relevant to his or her own farming operation.

TOOLS & SERVICES FOR OBTAINING NEW LAND RESOURCE INFORMATION

Most NZ farmers cannot use existing sources of LR information to further farm sustainability because such information rarely exists at a scale and quality suitable for farm planning and decision-making. Although being one of many constraints to a greater use of LR information, this unavailability precludes all other constraints (*e.g.* the ability to use LR information in farm planning), simply because the information itself must be at hand before it can be used.

A farmer has three principal choices available when existing sources of LR information are inappropriate or unavailable. Firstly, he or she may contract a service provider to go out and gather such information through survey and other methods of information collection. Secondly, depending on how a regional authority may choose to promote sustainable land management, a farmer may be able to link into a programme that involves the collection of new farm-scale information (*e.g.* environmental farm planning). Thirdly, it is entirely feasible that farmers may endeavour to collect such information themselves, provided they have the time, inclination and ability to do so.

In recent years there has been a steady emergence of organisations that can supply farmers with various resources and services for collecting or generating LR information particular to individual farms. Availability of these resources and services varies between organisations, and cost can range from a nominal or nil financial outlay, through to significant investments of $10,000 or more (*e.g.* for soil survey). As a result, there are many alternative options (as combinations of different resources and services) available to farmers interested in obtaining new LR information particular to their own respective properties.

This section aims to identify the types of survey tools, resources and services available to farmers interested in obtaining new farm-specific LR information, and to determine alternative 'best options' available for obtaining such information.

4.6. METHOD

Three methods are used. Firstly, several survey resources have been nominated as being relevant to the collection of farm-scale LR information, and are evaluated in terms of availability and utility towards both farm management and as a basis for land resource survey. The evaluation approach is similar to that used in the previous section, in that predefined criteria are applied to examine and discuss a given survey resource according to a form template (Figure 4.12, overleaf). Several survey and mapping services were also nominated for closer examination, and have been discussed according to their relevance towards the provision of LR information.

Secondly, a number of organisations involved in the commercial supply of survey resources and services were contacted by phone, to identify the type and cost of resources/services they provide. These commercial organisations were identified from advertisements contained in Telecom's 18 regional *Yellow Pages* phone directories (for 2001), according to classifications for *land information* and *aerial photography*. Brief phone interviews (5-10 minutes) were conducted over a 5 day period (03/10/2001 to 08/10/2001), according to a semi-structured questionnaire. Questions were based on identifying the type, cost, and characteristics of survey resources and services that a given business could provide to a farmer on request. Types of resources and services provided by various agencies are presented and discussed according to form template (Figure 4.13, overleaf).

Criteria	Description
Description	Description of the survey resource or tool.
Geographical coverage	An estimation of geographical coverage on a national basis (if relevant).
Available media/format	An indication of the types of media and format in which the resource may be obtained.
Notes	General attributes and characteristic features.
General utility to farmers	Description of how the resource/tool can be used in the collection of new LR information, and an indication of its practical worth or value.

Figure 4.12: Template structure used to examine and report on survey resources.

The third method targeted organisations and specialists who have the capacity to commercially undertake farm-scale soil or land inventory surveys (land survey services of regional authorities are examined in Chapter 6). These were nominated by Massey University pedologists (all two of them), and from the author's limited experience and contacts. A total of 12 potential organisations (or consultants) were identified, each of which was sent a questionnaire designed to elicit the cost of surveys at four levels of quality (bronze, silver, gold, and platinum) for a scenario farm (questionnaire included as Appendix IV).

Criteria	Description
Overview	Brief description of the organisation.
Aerial photography	Description of services related to the provision of aerial photography.
Orthophotography	Description of services related to the provision of ortho-corrected aerial photography.
Stereo pairs	Description of services related to the provision of stereo pairs (stereo pairs are used in the stereographic interpretation of landforms).
Land resource maps	An indication of the ability and willingness of an organisation for undertaking soil or land inventory surveys for individual farms.
Land feature maps	An indication of ability and willingness to provide land feature maps of individual farms (*e.g.* maps of slope, aspect, contours, etc.).
Physical resource maps	An indication of ability and willingness to provide maps and services relating physical resources (*e.g.* paddock maps).
Digitising service	An indication of ability and willingness to provide a digitising service to individual farmers.
Other services	Description of other relevant services particular to individual organisations.

Figure 4.13: Template structure used to report on survey resources and services available from different organisations.

Results from each of the three methods have been used to generate 'best option' scenarios for farmers interested in obtaining new LR information. Each scenario is based on a generic hill country property with a boundary extent that is readily depicted on a single 1:5,000 to 1:10,000 aerial photo, and includes provisions for obtaining a base map (*e.g.* an aerial photo), surveying land resources, and the final preparation of a map. Scenarios are evaluated in terms of cost, advantages, and disadvantages.

4.7. RESULTS & DISCUSSION

Six survey resources are discussed and reported according to the template format presented previously in Figure 4.12. Nine survey services are described and briefly discussed. A similar total of nine service-providers were contacted and engaged in telephone interviews, with the resulting information being ordered according to the form template designed for reporting (Figure 4.13). Supplementary information was also sourced through various internet sites (6 of the 9 organisations had websites as of October 2001). A total of twelve 'soil or land inventory survey' questionnaires were sent out to the nominated organisations/consultants, but only three responded.

Many of the organisations involved in the phone survey were reluctant to provide information, as they considered it to be commercially sensitive (particularly the costs of resources & services). For this reason, trading names have not been reported (rather, each organisation/consultant is assigned a numbered title such as *Organisation 1*, *Organisation 2*, etc.), and the amount of consistent information forthcoming from different organisations varied widely. This was further complicated by the intricate structure of larger organisations. An indication of cost would have taken time to prepare, or in some cases, the person interviewed was unable to make confident statements about services/resources provided by other sections within the organisation.

Results are particular to the 2001 year only, except where otherwise indicated.

4.7.1 SURVEY RESOURCES

4.7.1.1 Aerial photos (vertical)

Description

- Commercial and government vertical aerial photography. Includes:
  - Historical Crown aerial photography (from 1936 to present) held by NZ Aerial Mapping as the Aerial Film Negative Archive. Consists of >450,000 monochrome photos from 15,000 surveys flown at different scales; NZMS 3 aerial mosaics at 1:15,840; and a limited coverage of colour photos and assorted 1:10,000 scale photomaps.
  - Aerial photo collections held by private companies. As an example, the NZ Aerial Mapping Aerial Photography Collection contains 120,000 recently flown photographs.
  - New aerial photography is regularly collected under contract. This also includes small businesses that provide local aerial photography services.

Geographical coverage

- Extensive NZ wide. New high altitude photography captured at 1:25,000 or 1:50,000 is often flown on a regional basis by large companies. Smaller businesses readily undertake low altitude surveys for localised coverages (*e.g.* individual farms).

Available media & formats

- Original or scaled (*e.g.* enlarged) photos on either card or occasionally cloth backing. Sizes can range from small 150mm x 180mm photos up to long 1000mm x 3000mm canvases.
- Digital images from scanned negatives or photographs.

Notes

- Aerial photos exhibit distortions caused by relief displacement, camera tilting, and occasionally by processing method. Distortions are usually minor if the area of interest is directly under the camera lens when a photo is captured, but can be major towards the edges of a photo. Distortion tends to be more pronounced for hill and mountain land (relief displacement).
- Farm-scale aerial photos of hill country can exhibit a displacement of up to 74m (*i.e.* a positional accuracy of ±74m), and areas can vary by ±20% and up to ±40% in extreme cases (Krausse & Dymond, 1996).

General utility to farming

- An aerial photo represents a true record of a farm that captures the relative size and location of surface features in 2D (a 'snapshot in time'). It therefore represents a source of LR information unto itself, and can be used for farm planning, management and communication purposes. Indeed, farm aerial photos are quite possibly the most widespread and consistently used type of LR information in NZ farm management.
- The utility of aerial photography is limited by displacements and distortions at farm scales. In general, such photography cannot be used with a high degree of confidence to calculate areas and distances (although a greater degree of confidence can be associated with photography of flat land that has been captured directly under the lens during an aerial survey).
- Aerial photography is widely available at reasonably low costs. Even extensive surveys flown at scales of 1:50,000 can be enlarged to farm-scales (*e.g.* 1:10,000) to improve detail without a loss of clarity.
- Aerial photos are a valuable tool for mapping a farm's land resources, either through stereographic interpretation (via stereo photo pairs) or through field survey. A quality photo allows the identification of physical features (for reference) and topographical features (*e.g.* landforms).

4.7.1.2 Orthophotos

Description

- An orthophoto is a geo-referenced and displacement-corrected photomap usually derived from an aerial photo. Orthophotos retain the image qualities of the original photo but also include the additional geometric qualities of a map (*i.e.* they are referenced to a coordinate system expressed in real-world units). A well prepared orthophoto can be reliably used to calculate areas and distances.
- Aerial photo displacement and distortion caused by terrain relief, camera tilt and projection characteristics is removed through differential rectification, most often through GIS-based digital resampling and calculation.
- Land Information NZ (LINZ) is in the process of updating the NZMS260 topomap series from 1:25,000 orthophotos (captured at 1:50,000) at a resolution of 2.5m and accuracy standards of ±12.5m (mostly greyscale images but more recently in colour). These orthophoto images are freely downloadable from www.linz.govt.nz . Orthophotos date from 1994 to present, and an average of 20 new NZMS260 map size equivalents are being released each year.

Available media & formats

- Digital orthophotos are usually registered to a coordinate system (for use in GISs). LINZ orthophotos are an exception, but are readily registered to the NZ Map Grid using NZMS260 references.
- Printed paper maps at most paper sizes.
- Occasionally produced by sophisticated photo manipulation and processing techniques (as true 'ortho-photos'), but this is uncommon.

Geographical coverage

- High detail and quality orthophotos are now regularly being produced at 1m and 0.125m resolutions. However, imagery at 0.125m resolution is limited only to several urban centres, and imagery at 1m resolution is limited to occasional districts and regions such as Taranaki and Waikato (as of early 2003).
- Essentially any aerial photo can be used to produce an orthophoto image (at a cost). Hence, potential orthophoto coverage can be related to the existing coverage of aerial photography.

Geographical coverage (con.)

- Geographical coverage by LINZ orthophotos is extensive but not nationwide (Figure 4.14). Approximately 14.7 million hectares (55%) of NZ is currently represented, and ongoing coverage is being produced at an average rate of 2.4 million ha/yr (9% of NZ/yr).
- National coverage is only slightly more extensive when orthophotos from other organisations are included (as of 2001). This is due mainly to overlap of more detailed imagery, particularly for urban areas.

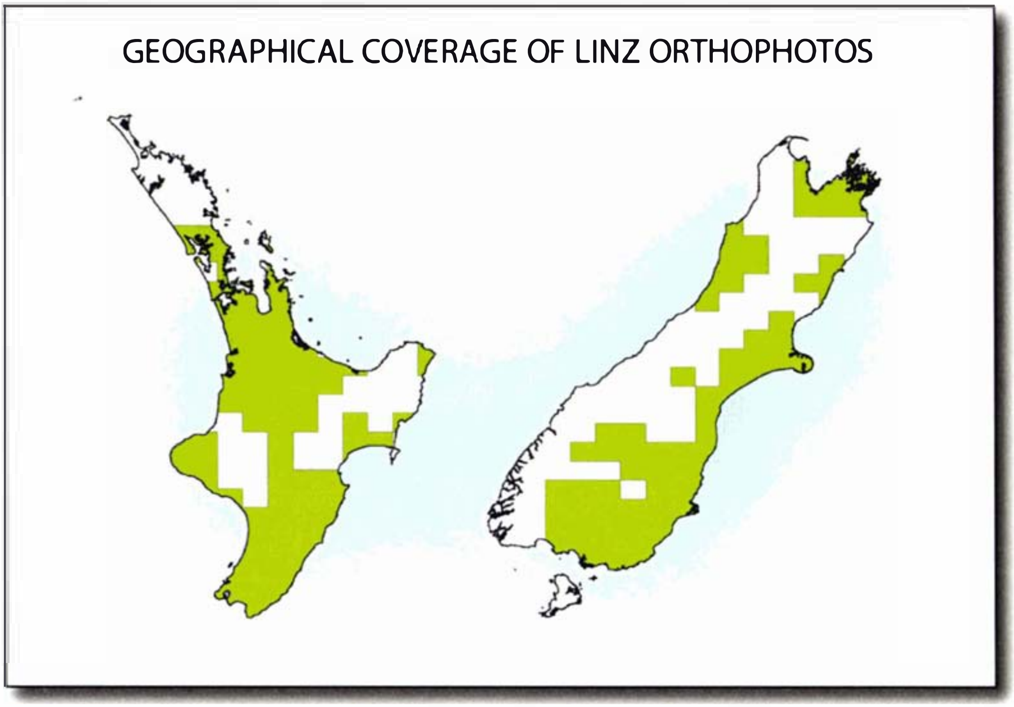

Figure 4.14: Coverage of LINZ orthophotos as of October 2003.

Notes

- LINZ orthophotos at 2.5m resolution (scanned from 1:25,000 enlargements) are adequate for paddock scale mapping of resources when enlarged to scales of around 1:20,000 to 1:10,000 (clarity decreases rapidly at larger scales). At this resolution landforms can be identified. However, some land features such as fence lines are not so clear.
- Orthophoto images at 1m resolution can be enlarged to scales of 1:10,000 to 1:5,000 without losing clarity. Fence posts and road centre-lines can be easily distinguished.
- Quality output of image orthophotos requires a high resolution printer (or plotter) capable of producing at least A3 sized prints. While this can be achieved with some desktop printers, wider formats generally require printing through commercial equipment (*i.e.* by printery and desktop publishing companies).

General utility to farming

- Like aerial photos, orthophoto images represent a record of a farm at a given point in time, and are a valuable tool for communicating, managing and planning. They are also immediately useable in GISs and farm management software, and provided they have been well prepared, they can also be used to calculate distances and areas with a high degree of confidence and accuracy. This type of reliability can be important for estimating fencing or piping costs, estimating gross margins (on a per hectare basis), predicting yields (including pasture production) and even buying and selling land.

4.7.1.3 Stereo pairs

Description	• Pairs of aerial photos or imagery that portray the same aerial scene at the same scale. When viewed through appropriate equipment (a stereoscope) the landscape appears to be in 3-D. Useful for viewing relief and delineating landforms or contours.
Geographical coverage	• As for aerial photo coverage.
Available media & formats	• Photograph pairs, digital pairs (for on-screen viewing – requires special hardware and software), and printed hardcopy pairs generated from some GISs.
Notes	• Not everyone can use a stereoscope. • 3-D visualisation of pairs through stereoscopes can exaggerate relief. • Using a traditional stereoscope with large photos can be difficult.
General utility to farming	• Useful for delineating landforms and features onto a base-map (i.e. one of the two photos) before undertaking survey field work. Limited use for other purposes.

4.7.1.4 Digital elevation models

Description	• *Digital elevation models* (DEMs) represent elevation and coordinate data (x, y & z) recorded in a form that can be used to represent landscape relief in 3-D. Sometimes they are referred to as Digital terrain models (DTMs), particularly when xyz data are linked with landscape attributes (as implied by the 'terrain' component). • DEMs can be prepared from topographical maps that record contour lines. As an example, 20m contours digitised from the NZMS 260 topomap series have been used to generate a 12.5m resolution DEM for NZ. • DEMs can also be produced from remotely sensed images using specialist computer hardware and software.
Geographical coverage	• Nationwide coverage at 12.5m grid resolution (derived from 20m contours), and other less detailed resolutions. Occasionally highly detailed DEMs from 5m contours may be generated for specific purposes.
Available media & formats	• Available in a range of GIS formats including vector (TINs or triangulated image networks), but most often as grid coordinates and images. • 2-D printouts simulating 3-D are possible (as sun-shaded DEMs).
Notes	• DEMs are more a source of data rather than a survey tool.
General utility to farming	• Little contemporary value to farming. Use of DEMs requires specialist skills and equipment. • Used to generate orthophoto images. • High potential future value for modelling landscapes, surface hydrology, and other processes related to farming.

4.7.1.5 Satellite imagery

Description	• Imagery captured from space via satellites owned and managed by a number of different international interests. • Satellites use a range of optical instruments to record image data from various parts of the electromagnetic spectrum. Imagery data needs to be processed and interpreted before providing useful information.
Geographical coverage	• National coverage when images from different satellites are combined. Individual detailed coverage varies between satellites. Coverage is continually being updated, but is influenced by cloud cover.
Available media & formats	• A range of GIS and image formats (from secondary suppliers). • Hard copy printouts.
Notes	• Satellite imagery of NZ can potentially be obtained on a daily basis (*e.g.* via NOAA). • Imagery is often expensive and requires processing before meaningful information can be obtained. • Resolutions, spectral data types, and costs vary widely between different satellites. Common resolutions range from 10-100m (*e.g.* SPOT & LANDSAT). Some satellites can capture high resolution images (1-4m), but these are uncommon for NZ.
General utility to farming	• Little contemporary value to farmers or farm survey. • High potential future value for monitoring crop and pasture dynamics (*e.g.* pasture cover, crop water stress, pest infestation).

4.7.1.6 Land feature maps

Description	• Maps of landscape features derived from DEMs and other imagery using GIS:
	  • Slope classes, where areas of land have been classified into any number of classes between 0-180^0.
	  • Aspect classes derived from the angle (0-360^0) a given landscape slope faces. Typically as an eight class system according to compass points (N, NE, E, SE, S, SW, W, NW) and one class for flat terrain.
	  • Contours at intervals proportional to the original data source or resolution.
	  • Landform classes derived by combining a number of datasets (*e.g.* slope, aspect, slope curvature, elevation) using predefined rules (*e.g.* show all land above 700m with slopes >28^0; north facing aspects; and areas >1ha). Also known as landscape modelling.

Geographical coverage	• Relates to the coverage of DEMs.
Available media & formats	• Digital images in GIS formats. • Printed hardcopy maps.

Notes

- The production of slope, aspect and contour maps is a reasonably quick and automated procedure in many GIS applications.
- Production of landform maps is considerably more involved and results can be variable. Isolation of landform units requires the simultaneous consideration of a number of land attributes and criteria (as rules). Predicted landforms require verification.

General utility to farming

- Slope, contour and aspect maps may be a useful tool to help manually delineate landform units. However, a detailed farm-scale DEM is required for reliable results (*e.g.* at 5m or less contours).
- High potential utility when used alongside other data for process modelling (*e.g.* linking pasture production to slope and aspect classes).
- Landform maps derived through GIS are time consuming and expensive to produce. Overall utility to farm management and resource mapping is minor.

4.7.2 Description of Survey Services

4.7.2.1 Image rectification

Image rectification represents an affordable means of accounting for some of the landscape distortion apparent with aerial photos (caused by relief displacement and camera tilt). However, it does not correct a photo to the same degree of accuracy attainable through *orthorectification.*

Partial rectification involves stretching or 'rubber-sheeting' a photo image to a set of Ground Control Points (GCPs). A GCP is real on-the-ground reference of a given point on the earth according to a standard coordinate system (*e.g.* northings & eastings, latitude & longitude). Through a GIS, GCPs are matched to features distinguishable on a photo image, and used to calculate and stretch the most likely representation of the on-the-ground landscape depicted by the image. However, without a comprehensive set of GCPs, partial rectification may unnecessarily over-stretch flat areas (which are more likely to be accurately depicted in the original photo *cf.* hill country) and under-stretch hilly terrain (*i.e.* the full range of stretching required is averaged by the inclusion of flat land) depending on the landscape make-up of the photo of interest.

An absolute minimum of three GCPs is needed for partial rectification, although a minimum of ten is often recommended. The more GCPs collected and used, then the greater the likelihood of a more accurate rectifying result. GCPs have often been taken from existing maps (*e.g.* NZMS 260 topographical maps) or databases (*e.g.* farm boundary extents from cadastral databases). This is quick and easy, but the final rectified photo will inherit the inaccuracies of the source map (*e.g.* NZMS 260 has a spatial accuracy of +/-22m, and the Digital Cadastral Database has a rural spatial accuracy of +/-10m for pegged survey points, and +/-30m for unpegged points), and inaccuracies created by map exaggeration of lines and points (which is done to make roads and other features legible at small scales). Greater accuracy can be achieved through Geographical Positioning Systems (GPS), although this is considerably more expensive.

A comprehensive and accurate collection of GCPs is a valuable resource – they can be used in the future to rectify (or orthorectify) any number of successive aerial photos, provided the landscape points or features they represent are distinctive and somewhat permanent.

4.7.2.2 *Orthorectification of images*

Orthorectification is one step-up from partial rectification. Not only does it include the use of GCPs, but also a DEM and particulars of the camera used to capture the original photo. Advanced orthorectification (the highest level rectification available) may also involve replacing GCPs with exact locational and height data of the aeroplane when a given aerial photo was captured.

The process of orthorectification can be described by visualising a DEM displayed in 3-D mode (*i.e.* the landscape appearing in 3-D), and then conceptually overlaying a photo image onto the DEM by aligning matching GCPs (*i.e.* GCPs of the image matched to the same coordinates on the DEM), and gradually stretching the photo image down across the 3-D relief until both are tightly layered. When subsequently portrayed in 2-D, areas have been stretched or compressed, and are more likely to accurately represent the on-the-ground landscape. Unlike partial rectification, flat areas are not unnecessarily stretched during the process.

4.7.2.3 *Photogrammetry (digital 3-D mapping)*

Photogrammetry is a process involving the use of specialist imaging equipment to view and map photography on-screen. It often involves high resolution photography displayed as pairs of stereo images that can be viewed in 3-D (using specialist workstations & viewing equipment). Highly accurate data can be mapped onto, or extracted from the images. Photogrammetry is used to produce DEMs, contours, detailed mapping of topographical features (*e.g.* Aeroplan 0.5 for urban areas), and orthophotos.

4.7.2.4 *GPS survey*

GPS (Global Positioning System) can provide almost instantaneous positioning on the earth from orbiting satellites and distance & time calculations. A readily obtainable handheld GPS can locate a point at around 15m accuracy (which is similar to the accuracy of LINZ orthophotos). A differential GPS can be used to obtain sub-metre accuracies (with the set-up and use of a transportable receiving station).

A contracted GPS survey typically involves differential GPS, with some agencies offering a full paddock mapping service (GCPs taken from fence-line corner posts). It is possible for farmers to undertake their own GPS surveys either using handheld GPS, or if more accuracy is required, by hiring a differential GPS (at about $300/day from some electricity companies).

4.7.2.5 *Soil survey*

Farm soil surveys involve a suitably qualified pedologist investigating a given farm's soil distribution and properties, and subsequently preparing a map and report for the farmer. Specific soils information and the quality of the survey will depend on the farmer's original reason for having the survey undertaken (and the overall cost). Soil surveys include a strong 'in-the-field' component, where the pedologist transverses the farm (one or many times) digging profiles, taking auger samples, and describing the soils identified.

4.7.2.6 *Land inventory survey*

Farm land inventory surveys are mostly undertaken as a basis for preparing environmental farm plans (as Land Resource Inventory and Land Use Capability Classification). Such plans have been prepared as a free service to farmers since the 1950s, and a large number of farms across NZ have already been mapped. Most of this mapping was undertaken by the now defunct catchment boards. Today, the service is still offered by some regional and unitary councils. Farm land-inventory surveys are examined in more detail in Chapters 5 & 6.

Some consultants will also undertake land-inventory surveys of individual properties. Depending upon how much the farmer is willing to pay, a consultant may be capable of mapping a full Land Resource Inventory (LRI) prior or during LUC classification, and they may be prepared to undertake a comprehensive evaluation of management options for improving farm profitability.

4.7.2.7 Assisted soil survey

Assisted soil survey involves farmers undertaking their own soil surveys under the guidance of professional soil surveyors. They carry the advantage of being comparatively less expensive, and farmers are likely to gain an understanding of their farms' land behaviour and production opportunities that would be broader and deeper than if they just paid someone else to do it for them. The main disadvantage being that assisted soil surveys require a commitment of time from the farmer, for both undertaking the actual survey and for upskilling themselves in the procedure of soil survey.

An example of assisted farm soil surveys is the Soils Underpinning Business Success (SUBS) program currently operating in the lower North Island (Chapter 7). This involves a group of farmers and four specialists (a pedologist, regional council land management officer, an agricultural scientist, and a farm business consultant) meeting once a month for about a year, to progressively work through a series of tasks. This includes each farmer mapping their soils firstly, which is then used together with other practical farm management considerations to design a set of Land Management Units (LMUs). Such units represent areas of a farm that behave and respond differently to different management based on soil properties (e.g. different fertiliser responses, pasture production, stock performance). The final step is using LMUs to evaluate different farm policy scenarios to identify one that meets the farmer's business and environmental objectives.

4.7.2.8 General image processing & output

Many farmers have the equipment and skills to undertake their own image processing (*i.e.* they have a computer). However, some do not, and it is likely that commercially available image processing services can provide comparatively higher quality image processing, or processing that a farmer is not capable of. Image processing & output services of value may include:

Scanning: Scanning is the capture of an aerial photo or paper map as a digital medium (e.g. .tiff, .bmp, .jpg, etc.) usually through a flatbed scanner. Readily available scanners are mostly capable of capturing A4 sized images, such that a large aerial photo requires the capture of a number of images and subsequent mosaicing. Commercially available scanning services have the capacity to scan large maps as single images.

Clipping: Clipping is a means of extracting a smaller portion of a larger image, and saving it as a separate image (*e.g.* extracting an image of a farm from a LINZ orthophoto).

Mosaicing: Mosaicing is edge-aligning and joining of separate images to form a single image.

File format conversion: Any given GIS generally has it's own particular native file formats (*e.g.* .shp, .dra, .e00, .ers, .ras, etc.), each of which requires conversion for use in other GIS platforms, or for use by farmers in farm management software.

High-end printing: Most home printers are restricted to 600dpi or less (usually less) and page sizes of A4 and perhaps A3. Commercially available printing services can range up to 1500dpi quality, and page sizes of A3, A2, A1, A0 and larger.

4.7.2.9 Cartography

Cartography is the art and science of producing maps. For this section, *land resource maps* are those that depict the distribution of soils, geology, land inventory, vegetation, hydrology, and other land resources. *Land feature maps* are those showing topographically related landscape features such as slope, contours, aspects, etc. *Physical resource maps* depict the location and extent of manmade features such as roads, fences, buildings, yards, paddocks, utilities, and other physical structures. As a service, these maps can be produced from public LR information sources outlined in Section 4.4, or as the result of contracted survey.

4.7.3 COMMERCIALLY AVAILABLE SURVEY RESOURCES & SERVICES (2001)

Two methods were used to identify the type and cost of survey resources and services that can be obtained from commercial businesses around NZ. The first involved a short telephone survey, the results of which are reported here as *general services & survey resources.* The second involved a mail questionnaire sent out to professionals and organisations capable of undertaking soil and/or land resource surveys (excluding regional authorities). Results from this questionnaire are reported as *soil and land-inventory survey* services.

4.7.3.1 General services & survey resources

A total of nine service providers were identified from *land information* and *aerial photography* telephone-directory advertisement classifications. Representatives from each were contacted by phone in late 2001, and asked if their organisation could provide farmers with the previously discussed types of survey resources and services. Respondents were encouraged to elaborate on their services and resources when responses were in the affirmative. They were also asked to provide an estimate of cost.

All nine service providers responded positively, although some of the larger national and multi-national businesses were unwilling or unable to divulge complete information. Either the information was considered commercially sensitive (particularly costs), or the representative could not make confident statements about all relevant sections of the business. In contrast, smaller regional organisations were very forthcoming, and were readily able to outline their business's full complement of services and survey resources.

Results reported below are particular to the 2001 year only. Services and costs have changed markedly since this time, and many other organisations (particularly smaller specialist organisations) have now come into operation. Trading names are not used because this study does not seek to compare the services and pricing of different organisations with each other.

4.7.3.1.1 Business No. 1

Overview

- A large organisation that operates on a national level, with a business focus that is primarily orientated towards the provision of a wide range of services to the agricultural industry. Capable of providing a number of high quality land-resource related services, through high-end GIS capabilities and mapping data sourced from other organisations.
- Business No.1 were reluctant to provide specific detail concerning their services, and steadfastly refused to give any estimates relating to cost.

Aerial photography

- Capable of providing aerial photos sourced from other organisations.

Orthophotos	• Can and will supply orthophotos sourced from other organisations. • Capable of producing tailored orthophoto images on request. • For projects (*e.g.* a complete farm mapping exercise), the cost of obtaining and orthorectfying an aerial photo would be weighed against the cost of obtaining existing orthophotography.
Stereo pairs	• Not provided.
Land resource maps	• Can provide single or multifactor land resource maps of individual farms using data taken from the NZLRI. Will provide this as paper maps or digital extracts. • Would prepare a report to accompany any land resource maps if it was requested. • Prepared to engage the services of other organisations for detailed land resource surveys (contracted survey through a third party).
Land feature maps	• Capable of producing single factor maps of contours, slopes, aspects and landforms, but don't generally offer this as a service to farmers. Land feature maps derived from a 12.5m resolution DEM.
Physical resource maps	• Can provide physical resource maps according to farmer specifications, with a high spatial accuracy (degree of accuracy and method of data collection was not volunteered).
Digitising service	• Full digitising service available. • Broad estimate of 1-2 days to prepare a digitised farm map (when supplied with an appropriate base map).
Other services	• Land cover maps derived from the LCDB. • Have access to the National Soils Database, AgriBase (a database based on cadastral parcels with agricultural attribute information about individual farms; originally designed to provide core information during national animal health emergencies). • Capable of providing high-end GIS services that span information management, analysis, and map production.

4.7.3.1.2 Business No. 2

Overview	• A large nationwide organisation that specialises in aerial photography. They maintain an extensive collection of photography, and offer a full suite of services ranging from photo supply through to sophisticated generation of maps and GIS databases.
Aerial photography	• Can provide aerial photos at scales ranging from 1:100 to 1:50,000. They have their own photo capture and processing capabilities. • The core collection of recent aerial photography was flown at 1:27,500. At the time of the interview coverage of this collection was limited to Waikato, Auckland, Taranaki, Manawatu-Wanganui, part Wellington, and some of the South Island. Other areas of NZ were represented by previous collections.

Aerial photography (con.)	• An A4 sized enlargement from the 1:27,500 collection would cost approximately $50, and $200 for an A1 sized enlargement (594 x 841mm). • Capable of capturing high resolution aerial photos (up to 0.125m ground resolution) but this tends to be expensive and limited to urban and/or special project areas.
Orthophotos	• Can provide high resolution and high accuracy orthophoto images. • Offer budget orthophotos derived from the 1:27,500 scale aerial photos, at a 0.4m resolution and a +/-10m accuracy. For an individual farm, such an orthophoto would cost around $600, and would depend on coverage. • Prepared to undertake orthorectification on request.
Stereo pairs	• Can supply according to the coverage and availability of aerial photography. Cost for a stereo pair was estimated at $80.
Land resource maps	• Unfamiliar with such a service, but if a specific request was forthcoming from a farmer, then they would endeavour to provide such a service. • They have the capability to prepare single of multifactor land resource maps derived from either the NZLRI or Land Environments NZ (then called Environmental Domains). • The organisation is not prepared to field-check maps derived from historical land resource surveys.
Land feature maps	• Very capable of producing high quality land feature maps (topographical maps). • The cost is dependent on the availability of existing DEMs or contour data at farm scales. In a 'best case' scenario, a land feature map could cost around $1000, but in a 'worst case' scenario it could cost between $10,000 and $15,000 (*i.e.* the complete cost to capture a new aerial photo; orthorectification; generation of contours; and generation of a DEM).
Physical resource maps	• Very capable of producing high quality physical resource maps. Cost is dependent on available resources and photo coverage, and the degree of quality required by the client.
Digitising service	• Prepared to offer a digitising service, along with any other GIS related services. Cost of GIS services was given at $50/hr.
Other services	• Photomontage – before and after landscape modelling to aid resource consent applications. • Detailed forestry monitoring services.

4.7.3.1.3 Business No. 3

Overview	• A national serving organisation that specialises in aerial photography and GIS services, now operating as two separate entities (one focusing on GIS services and the other on aerial photography). GIS services are provided mainly to councils and large companies.
Aerial photography	• Maintain an extensive collection of aerial photography with nationwide coverage. The collection varies according to scale, age, and types of photo available for a given locale. • Regularly undertake aerial photo surveys and in-house processing.

Aerial photography (con.)	• Recent photography flown at 1:8,000 to 1:50,000 scales for most of NZ. Overall 'good coverage' except for Taranaki. • Capable of high resolution photography (0.125m) but this is expensive, and is currently limited to a select few urban areas. • Examples of standard aerial photo charges include: $24.75 for contact prints; $81 for A4 sized enlargements (any scale); and digital images scanned from enlargements at $180. Will also provide A3, A2 and A1 sized photo enlargements.
Orthophotos	• Have a limited collection of existing orthophotography, mostly at high resolutions for urban areas. At the time of the interview, plans were in place to capture all of rural NZ at a 1m resolution and +/-3m accuracy (and urban areas at higher resolutions). • Capable of preparing orthophoto images from any aerial photo on request.
Stereo pairs	• Available as double contact prints at $50 per pair.
Land resource maps	• Not available.
Land feature maps	• Capable of preparing detailed land feature maps. However, it would be unlikely that they would offer this as a service to individual farmers.
Physical resource maps	• Capable but not willing.
Digitising service	• Capable of providing a digitising service. However, as a service to farmers, willingness to provide this service would vary on a case by case basis.
Other services	• GPS survey (including RTK-GPS which takes multiple readings while moving). • A wide range of GIS services. However, as with other services, Business No.3 prefers to focus on contracts with other large organisations rather than individual farmers.

4.7.3.1.4 Business No. 4

Overview	• A national organisation capable of providing a full complement of land-resource related services, ranging from in-the-field survey through to high-end GIS capabilities. • Business No.4 was decidedly uncooperative and suspicious of the telephone interview. They provided little information suitable for reporting.
Aerial photography	• Not specified. Likely to obtain their aerial photography from outside sources.
Orthophotos	• Not specified, but they have the capability to undertake orthorectification.
Stereo pairs	• Not specified. Likely to obtain stereo pairs from outside sources.

Land resource maps	• Capable of providing single and multifactor maps derived from existing sources of LR information described previous in Section 4.4. • Retail a wide variety of published maps, including NZLRI Worksheets and soil maps. • Capable of undertaking farm-scale soil and/or land inventory surveys at a high degree of quality. This can include the inhouse collection and provision of detailed attribute information (*e.g.* measurement of soil attributes).
Land feature maps	• Capable, but it was not specified if they would be prepared to generate land feature maps for individual farmers.
Physical resource maps	• Not specified.
Digitising service	• Not specified. Certainly capable of providing a wide range of GIS related services.
Other services	• None specified.

4.7.3.1.5 Business No. 5

Overview	• An association of four businesses located in Manawatu, Rotorua, Hawkes Bay and Dunedin, who specialise in the provision of farm aerial photography and physical resource maps (namely paddock maps). Each business operates on a regional scale.
Aerial photography	• Provide affordable aerial photography on a regional basis for Manawatu-Wanganui, Hawkes Bay, Bay of Plenty and Otago. Partial coverage for other areas on a case by case basis. • 'Standard' aerial photography captured at 1:25,000 and 1:27,500 (obtained from other sources). Cost of standard photography for an individual property is $60 for an A3 sized photo; $130-150 for A2 size; and images on CD-ROM at $45/CD. • Specialist low altitude photography of individual farms flown on request. This is for areas that are not covered by the 'standard' photos, or for farms that require very up-to-date photography. Aerial survey undertaken when 10-15 clients have made a request. Cost to each farmer is $130-$150 for an A2 sized photo.
Orthophotos	• Not prepared to produce orthorectified photos, but will undertake partial rectification. Ground control points taken from NZMS 250; cadastral databases; and in special cases a GPS may be used.
Stereo pairs	• Not available.
Land resource maps	• Access to NZLRI Worksheets & Legends. • The Manawatu business is capable of undertaking land inventory surveys.
Land feature maps	• Service not provided.

Physical resource maps

- Offer a full service for the production of paddock maps. Involves consultation with the farmer; provision of an aerial photo; digitising fence lines and other features; partial rectification to cadastral boundaries; A2 sized photomap; and a booklet of A4 maps.

Digitising service

- Offer a digitising service.
- For a farmer who provides a draft map with fence lines, a digitising service would cost $250-$300 per map (includes partial rectification; an A2 print; and an A4 booklet of maps).

Other services

- GPS survey (at +/-1m accuracy) and conventional theodolite-based survey (+/-0.01m accuracy).
- Also provide a map verification service to other (larger) businesses.
- May provide cadastral and related legal information concerning land parcels.

4.7.3.1.6 Business No. 6

Overview

- A small regional business based in the Manawatu that specialises in low altitude photography. Capable of providing some GIS related services.

Aerial photography

- Focus on the provision of up-to-date and detailed aerial photography for individual properties. Current photo collection is limited to existing farm and forestry clients.
- Low altitude flying using medium format cameras. Scale is dependent on the size of the farm, but a common scale is approximately 1:5,000 or the equivalent of 3-4km^2. Photos captured in colour unless otherwise requested (greyscale photos are actually more expensive).
- Aerial surveys undertaken on request, but specific dates dependent on the weather, and being able to engage enough clients at one time to justify a flight.
- If a farm of interest can be captured as one photo (dependent on farm size), then cost is $350-$400 for a 50cm x 50cm photo. Scanned photo images burned to CD-ROM at $300 per photo.

Orthophotos

- Not prepared to produce orthorectified photos, but will undertake partial rectification. Ground control points taken from NZMS 250 or cadastral databases.

Stereo pairs

- Not provided.

Land resource maps

- Not provided.

Land feature maps

- Not provided.

Physical resource maps

- Consult with the farmer to produce physical resource maps depicting fence lines, structures, tracks, etc.
- Baseline cost for a physical resource map is $200 per map, and then a further $10/paddock for hill country, or $5/paddock for flat terrain.

Digitising service

- Digitising service available at a rate of $60 per hour.

Other services

- None specified.

4.7.3.1.7 Business No. 7

Overview

- A regional business with close academic and research links, capable of providing a variety of land-resource related services. Specialise in high-end GIS services, the design and application of land drainage, GPS survey, and land resource survey.

Aerial photography

- Generally will not provide aerial photography unless it is part of a broader service. Photos obtained from other sources, although specialist paddock-scale photography may be flown on request as part of a land drainage service (low altitude photos using an unmounted 35mm camera).
- Maintain an historical collection of 1:25,000 scale aerial photography for much of the North Island.

Orthophotos

- Will provide LINZ orthophotos clipped to farm extents and calibrated to the NZ Map Grid, as part of a broader service.
- Capable of inhouse orthorectification on request.

Stereo pairs

- Generally not provided, unless obtained from an outside source.

Land resource maps

- Capable of producing multifactor or single factor land resource maps derived from the NZLRI and other databases. The limitations of such maps would be clearly explained on the maps themselves.
- May undertake field checking of historical maps and survey data on request.
- Will prepare explanatory and descriptive reports if necessary.
- Capable of providing a full survey service as one package (field survey and final map preparation).

Land feature maps

- Able to produce single factor maps of slope, aspect, and contours derived from a DEM or existing contour data at 20m intervals.
- Currently have DEM data at 12.5m resolution for much of the lower North Island. Capable of generating DEM coverage of other areas from 20m contours if required.
- Capable of capturing highly detailed topographical data using RTK-GPS (xyz coordinates at +/-0.01m accuracy) and processing into DEMs, contours, and terrain maps.

Physical resource maps

- Will digitise fence lines drafted by a farmer onto an aerial photo.
- Capable of undertaking detailed GPS survey of fence lines. Locally, this may involve a cost of around $25-$35 per hour. For GPS surveys requiring considerable travelling time, the service is only available for surveying at least four farms in one day (*i.e.* four farms in the same general area need to be engaged at once). If this can be achieved, then a GPS survey at +/-1m accuracy costs $250/farm, and $500/farm at +/-0.01m accuracy (based on a general charge-out of $1,000 and $2,000 per day respectively).

Digitising service

- Capable of providing a digitising service particular to individual clients. This can include digitising onto a partially rectified aerial photo, or reinterpretation/digitising onto existing orthophotography (*e.g.* LINZ orthophotos).
- Cost of digitising depends on individual properties. A 'ball park' figure was given as $300-$500 for the translation and digitising of land units for a hill country farm from an aerial photo to a LINZ orthophoto.

Other services

- Have access to the National Soils Database and other similar databases.
- Provide a full and professional drainage planning service.
- Undertake EMS surveys using an electrical magnetic conductivity sensor and RTK-GPS.

4.7.3.1.8 Business No. 8

Overview

- A multi-national organisation specialising in GIS processing; the production of digital orthophotos and DEMs; and the generation of spatial databases and data under contract for other organisations.
- Business No. 8 was not particularly cooperative. The representative interviewed was not prepared to make confident statements about the full complement of services and survey resources that they could provide.

Aerial photography

- Not specified.

Orthophotos

- Retail geo-referenced LINZ 2.5m orthophotos as 5 x 7.5km tiles on CD-ROM. One tile costs $50, while a series of tiles with an extent equivalent to that of a single NZMS 260 sheet costs $250. [Note: LINZ orthophotos are freely downloadable from www.linz.govt.nz].
- Colour orthophoto images at 1m resolution and +/-3m accuracy for Wellington and Christchurch urban centres. Greater coverage planned in the future. Distributed on CD-ROM at $150 per tile (5 x 7.5km equivalent) or $3,200 for a NZMS 260 extent equivalent.

Stereo pairs

- Not specified.

Land resource maps

- Not specified.

Land feature maps

- Not specified.

Physical resource maps

- Not specified.

Digitising service

- Not specified.

Other services	• GIS consultancy services and training. • Provision of national datasets such as the DCDB, Land Cover Database, and Topodata. • National coverage of 12.5m resolution DEMs derived from 20m contours.

4.7.3.1.9 Business No. 9

Overview	• A small regionally-based business that focuses exclusively on the capture and provision of aerial photography.
Aerial photography	• Provide 1:15,000 to 1:25,000 scale photos for the upper-eastern North Island. • Extensive coverage of Bay of Plenty, Gisborne & East Cape, and part Waikato. Plans to capture Northland over the 2001/02 summer.
Other services & resources	• No other services provided.

4.7.3.2 Soil and land inventory surveys

Commercial organisations and individual professionals with a known capacity for undertaking soil and/or land inventory survey were sent a postal questionnaire (Appendix IV) designed to elicit the character and cost of their survey services at four levels of quality (bronze, silver, gold and platinum) for a scenario hill-country farm. The questionnaire was sent to a total of 12 organisations/professionals located throughout NZ in October 2001.

Only three of the twelve responded. The three responses were from individual consultants; no response was forthcoming from any large organisation. Those who did reply, chose to describe their services in their own individual manner – the format and structure provided in the questionnaire was only loosely adhered to in most cases. This suggests an inappropriate questionnaire design, which could possibly explain part of the low response rate.

Despite these problems, those who did respond were able to provide an insight into some of the survey services available to farmers in 2001.

4.7.3.2.1 Business No. 10

- Description: A South Island based consultancy business specialising in soil survey for forestry and horticulture.
- Prepared to undertake both soil and/or land inventory survey for individual farmers. The degree of survey detail and costs would vary on a farm-by-farm basis according to management objectives, farm size, location, etc.
- Undertake soil-climate surveys using climate data loggers. Capable of undertaking land evaluations for horticultural and viticultural crops.

- Soil maps and reports are prepared according to user specifications. Soil descriptions and the choice of soil attributes to be measured are land-use orientated rather than soil classification orientated. Maps and reports 'should be practical and useable'.
- Basic land inventory mapping takes approximately 0.5 of a day in the field, and another full day in the office (for survey design, map preparation, and report preparation). Such mapping is only undertaken occasionally, mostly for forestry, and usually only for specific areas of a farm.
- A large proportion of their soil survey service focuses on mapping for intensive lowland land-uses such as viticulture and horticulture. Hill country surveys tend to be for forestry uses, and very little is undertaken for pastoral purposes.
- A survey generally involves an assessment and description of soils, climate (particularly temperature), and water supply.

4.7.3.2.2 Business No. 11

- Description: A North Island based consultancy business specialising in soil survey for intensive land uses such as viticulture.
- Do not provide a service for land inventory survey.
- Prepared to undertake soil surveys of individual farms at three levels of intensity and quality: bronze, silver, and an aggregation of gold and platinum (see Appendix IV for definitions). Cost estimates for a scenario 500ha hill country farm were given at $2,500 (bronze level), $6,500 (silver), and around $10,000 for the highest survey intensity and quality.
- Physical and chemical analyses for soil attributes can be undertaken on request, but this would be through a laboratory. Laboratory charges are passed onto the farmer/developer at cost. An additional cost may be charged for sampling, and the interpretation of laboratory results.
- A soil survey results in a map and report. Reports are prepared for all levels of survey intensity and quality, and involve an interpretation of soil attributes as they relate to 'present and future land uses'.

4.7.3.2.3 Business No. 12

- Description: A North Island based consultancy business that specialises in a wide range of services relating to land resource investigations, soil conservation, and the environmental management of land and water.
- Prepared to undertake soil and/or land inventory survey if a specific request is made by a farmer. However, it was considered that both these types of survey have inherent limitations towards farm planning and management. To accommodate some of these limitations, the consultant had developed a tailored system of hill-country farm survey that combines elements of both soil and land-inventory survey, in a way that seeks to more closely link the collection of new LR information to it's use in farm decision-making.
- As a response to the questionnaire, the consultant described his system and service of hill-country farm survey according to each of the four levels of intensity/quality. This was done in concise detail, so is reported *verbatim* as Figure 4.15 (overleaf). Comments have been added where necessary in enclosed [*square*] brackets.

HILL COUNTRY FARM SURVEYS

For a 500 hectare farm as per Andrew Manderson's specifications.

Bronze level
Basic farm map depicting landforms, with an attached key indicating geology, associated soil types, and land use capability. Moderate confidence in accuracy of the map.

Half day air photo interpretation [*a.p.i.*]
Quarter day map compilation plus [*map*] key
0.75 days total @ $360 per day
[*total for the scenario farm = $270*]

Remarks: 500 hectares can't be mapped on-farm in half a day. [*The*] only way to do a basic survey in this timeframe is by a.p.i, transferring detail onto an unrectified aerial photo or halftone photo-mosaic or orthophoto (where available).

Silver level
Detailed farm map depicting landforms, with an attached key indicating geology, associated soil types, and land use capability. High confidence in accuracy of the map.

Full day field mapping
Half day map compilation plus key
1.5 days total @ $360 per day
[*total for the scenario farm = $540*]

Remarks: Between 200 and 1000 hectares can be field-mapped in a day, depending on access, weather conditions and length of daylight. The maps are compiled on unrectified aerial photos or halftone photo-mosaics or orthophotos (where available).

Gold level
As per silver level but with vegetation/land use added; map digitised and entered into GIS; plus extended legend; plus grazing and forestry production estimates; plus outline of land use options.

Full day field mapping
Half day map compilation plus key
Half day GIS entry
Half day production estimates
3 days total @ $360 per day
[*total for the scenario farm = $1,080*]

Remarks: These [*are*] equivalent to the new-style farm conservation plans presently undertaken by several regional authorities.

Platinum level
As per gold level, with economic evaluation of one alternative land use scenario *cf.* evaluation of present use (which needs to be modelled for comparison).

Full day field mapping
Half day map compilation plus key
Half day GIS entry
Half day production estimates
Half day outline of options
Half day preliminary discussion of options with farmer
Two days modelling alternative *cf.* present scenario
Half day discussing results with farmer
6 days total @ $360 per day
[*total for the scenario farm = $2,160*]

Remarks: These are equivalent to the sustainable land use plans presently undertaken by several regional councils [*see Chapters 5 & 6*].

Figure 4.15: Four levels of survey quality/intensity for hill-country farm survey as stated by the third consultant.

4.7.3.3 Summary & Discussion

A variety of commercial services and survey resources are available from the businesses examined (summarised as Table 4.3). Two of the businesses specialise in the capture of high-altitude aerial photography over extensive areas (and in-house photo enlargement & processing), at scales suitable for farm management and mapping (when enlarged), and at a reasonable and affordable cost (≈$200/farm for an A1 size photo). However, some parts of the country do not have recent coverage, and aerial surveys over extensive areas are not commonly undertaken on an annual or routine basis. Hence, while extensive coverage means that farmers can be confident of sourcing a reasonably priced aerial photo more-or-less on request, the photo they receive may be dated by five years or more.

The most up-to-date aerial photography can be obtained from the three businesses that undertake low-altitude aerial surveys of individual farms on request. One business provides such photos at very low cost ($130-$150/farm), while another was comparably more expensive ($350-$400). The limitation of this service is having to wait for requests from 10-15 clients before an aerial survey will be flown.

Three businesses also provide aerial photos sourced from third parties. The risk of such a service to farmers is having to pay an added-on agency or sourcing fee, although one business suggested that they provide third-party photography at cost only.

Orthophotography is comparatively less available, with only one business having an orthophoto collection with detailed and extensive coverage (excluding LINZ orthophotos). However, four businesses were capable of undertaking orthorectification on request; two indicated that they would provide geo-referenced LINZ orthophotos; and a further two regularly undertake partial rectification specifically for farm aerial photography. Orthophotos are expensive ($600-$1000/farm), but cheaper added-value LINZ orthophotos are also available (the added-value being geo-referencing and clipping to a manageable image size).

Five businesses can provide *land resource maps* to farmers, three of which are also capable of undertaking farm land-resource surveys. A similar five indicated that they would construct farm maps of land resources from existing databases (particularly the NZLRI), which is a concern because many such databases are not suitable for application at farm or paddock scales (Section 4.4). Only three businesses indicated that they would prepare *land feature maps* as a service for farmers, and seven were capable of preparing *physical resource maps* (two of which specialise in the production of paddock maps). Most businesses were prepared to offer a digitising service at around $50-$60 per hour, or $250-$500 per farm (depending on farm size and terrain).

Some of the larger organisations were very capable of providing various services and resources to farmers, but were unlikely or unwilling to do so because farmers were not their targeted market. Conversely, smaller businesses engaging or specialising in a farmer clientele were willing, but were generally less capable of providing a full range of resources and services (particularly high-end GIS related services).

The mail-questionnaire response concerning land resource surveys was disappointing – while at least 12 organisations and consultants are known to have commercial capabilities for undertaking such surveys, only three chose to respond. Of these three, two specialised in soil survey for intensive lowland land uses (horticulture & viticulture), while the other had developed his own unique system of surveying land-resources for hill country farming. All three suggested that their survey service was part of a complete land evaluation package, tailored to suit particular land uses and individual farms. One consultant provided cost estimates of $2500, $6500 and $10,000 for three levels of soil survey quality, while another gave estimates of $270, $540, $1080 and $2160 for four levels of 'hill country farm survey'.

Table 4.3: Summary of commercially available survey resources and services for nine NZ businesses.

	Business scope	Aerial photography	Orthophotos	Stereo pairs	Land resource maps	Land feature maps	Physical resource maps	Digitising services
Business No. 1	• Large organisation operating on a national level	• Source from 3rd party.	• Source from 3rd party • Capable of inhouse orthorectification	• Service not provided	• Extracts or maps from existing databases • 3rd party surveying if necessary.	• Capable of inhouse production of land feature maps from 12.5m res. DEM	• High quality maps on request according to a given farmer's specifications	• Digitising service available
Business No. 2	• Large organisation operating on a national level	• Capture & process their own photography • Extensive coverage at 1:27,500 • $50 for an A4 size farm photo, $200 for an A1 size	• Undertake inhouse orthorectification on request • 'Budget' orthophotos available (0.4m res., ±10m acc., derived from 1:27,500 photos).	• $80/pair	• Capable of providing this service • Extracts or maps from existing databases	• Capable of inhouse production of land feature maps, and the capture & processing of primary DEM data. • Generating a farm DEM and subsequent maps would cost between $1,000 to $15,000 depending on existing data sources.	• Capable of inhouse production of physical resource maps.	• Digitising service available at $50/hr
Business No. 3	• Large organisation operating on a national level	• Capture & process their own photography • Extensive coverage at 1:50,000 & some at 1:8,000 • $25/ contact print, $81 for an A4 farm photo, $180 for a farm photo image on CD	• Undertake inhouse orthorectification on request • Limited collection of existing orthophotography, mostly for urban areas only	• Double contact prints at $50/pair	• Service not provided	• Capable, but unlikely to provide this as a service to farmers	• Capable, but unlikely to provide this as a service to farmers.	• Capable, but unwilling to provide this as a service to farmers.
Business No. 4	• Large organisation operating on a national level.	• Not specified.	• Not specified	• Not specified	• Extracts or maps from existing databases • Capable of undertaking detailed surveys of farm land-resources • Inhouse production of maps	• Not specified	• Not specified	• Not specified
Business No. 5	• A collection of regional businesses operating collaboratively.	• Provide third party photography (high altitude) for 4 regions • Prepared to capture low altitude photography on request • 3rd party photos at $60 for A3 size, $130-$150 for A2 size, images at $45/image • Specialist low altitude photos at $130-150/farm	• Not prepared to undertake inhouse orthorectification • Will provide partially rectified photo images on request	• Service not provided.	• Extracts or maps from existing databases • Capable of undertaking land inventory surveys • Inhouse production of maps.	• Service not provided.	• Specialise in the production of paddock maps for individual properties • Undertake GPS survey (±1m) & conventional survey (±0.01m)	• Digitising service available at $250–$300 per map
Business No. 6	• Small regional business	• Low altitude photography flown on request, mostly at 1:5,000 scale. Regional focus. • $350-400 per farm photo (50 x 50cm).	• Not prepared to undertake inhouse orthorectification • Will provide partially rectified photo images on request	• Service not provided	• Service not provided	• Service not provided.	• Specialise in the production of paddock maps for individual properties • Cost at $200 per map, plus $10/paddock for hilly terrain, or $5/paddock for flat terrain.	• Digitising service available at $60/hr
Business No. 7	• Regional business occasionally operating on a national level	• Source from 3rd party • Generally do not provide photography unless it is part of a broader service	• Undertake inhouse orthorectification on request • Will provide geo-referenced LINZ orthophotos clipped to farm extents	• Service not provided	• Extracts or maps from existing databases • Capable of undertaking detailed surveys of farm land-resources • Inhouse production of maps.	• Capable of inhouse production from DEMs or vector contours. • Undertake RTK-GPS survey (±0.01m) to collect highly detailed topographical data	• Capable of inhouse production of physical resource maps • Undertake GPS survey (±0.01m & ±1m)	• Digitising service available. General estimate at $300-$500 for a hill country farm.
Business No. 8	• Large organisation operating on a national & multinational level.	• Not specified.	• Retail geo-referenced LINZ orthophotos @ $50 per tile (37.5km²) & $250 per NZMS 260 sheet (1,200km²).	• Not specified	• Not specified.	• Not specified.	• Not specified.	• Not specified.
Business No. 9	• Small regional business	• Provide 1:15,000 to 1:25,000 aerial photography for the upper-eastern NI	• Service not provided.	• Service not provided	• Not provided	• Service not provided	• Service not provided.	• Service not provided.

4.7.4 Alternative & Best Option Scenarios for Pastoral Farmers

There exists a wide variety of survey resources and services available to farmers interested in obtaining new LR information particular to their own respective properties. For a complete LR information collection exercise, a number of *alternative options* can be designed for three key steps – the selection of an appropriate mapping base; undertaking an in-the-field resource survey; and the preparation of a final map. Likewise, the most feasible alternatives can be used to reconstruct 'best option' scenarios for different purposes.

Previous results reported in this chapter have been used to identify and appraise alternative options for obtaining aerial photos & orthophotos; for undertaking farm resource surveys; and for final map preparation. Alternatives are appraised in terms of advantages, disadvantages, and estimated costs. In turn, three 'best option' scenarios have been erected to examine complete packages for obtaining new farm LR-information, according to increasing tiers of cost and quality.

4.7.4.1 Alternative options

4.7.4.1.1 Alternative options for aerial photos & orthophotos

Five principal option categories are possible for obtaining aerial photos and orthophotos. They include low cost options; existing aerial photo collections; 'flown on request' aerial photography; partially rectified photo images; and commercial orthophotography (Table 4.4).

Low cost options include either a LINZ orthophoto, or a copy of an existing aerial photo already held by the farmer. LINZ orthophotos are readily downloadable from www.linz.govt.nz for free, but they require internet access, geo-referencing, and additional GIS and output processing (clipping, enlarging and printing). It is possible that a farmer can achieve this with free GIS software (*e.g.* Map Maker Gratis at www.mapmaker.com), internet access, and an investment of time. Alternatively, a geo-referenced LINZ orthophoto extract can be sourced from a business for around $50-$120 (based on an hourly rate of $50-$60 for GIS processing). LINZ orthophotos are limited by their coverage (a farmer may not be able to obtain a LINZ orthophoto for his/her farm), and a lack of clarity for detailed mapping. However they carry the advantage of being affordable, and can be used to derive reasonably reliable distance and area information.

Many farmers already have an aerial photo of their farm, either for direct use as a farm management tool, or as a wall feature hanging in the lounge. Such photos tend to be of high quality (in terms of resolution, detail, colour and enlargement size), and can therefore be used as a mapping base without additional or significant financial outlay. However, a minor cost ($20-80) may be involved in copying, scanning and printing the original (unless an original was directly available for use), and it is not unusual for the photo to be out-of-date. Further, without GIS-related processing, information concerning areas and distances may not be reliable.

Purchasing a new photo from ***existing aerial photo collections*** can also be inexpensive (around $60-$115 for an A3 sized photo). Coverage is extensive at scales suitable for enlargement to depict individual properties in detail. Two businesses maintain extensive collections, and most other businesses can source these photos as a 3rd party service (*i.e.* they are very easy and convenient for a farmer to obtain). The main limitation being the misrepresentation of areas and distances inherent to aerial photos, and the infrequency of extensive aerial photo surveys (meaning a farmer may have to settle with an out-of-date photo). Further, landscape features often do not align well in situations where a farm was not originally captured on a single aerial photo negative (*i.e.* two photos need to be joined to portray the farm in its entirety), as distortions tend to be most pronounced towards the edges of aerial photos.

Alternative options	Estimated costs: Image	Estimated costs: Hardcopy	Advantages	Disadvantages	Other comments
1 Reproduction of farmer's existing farm aerial photo	• Possibly free • $20-$40 for A3 original • $50-$80 for A2 original	• $2-$10 A3 print • $20-$50 A2 print	• Low cost • Readily accessible	• Areas & distances derived are likely to be inaccurate • Possibly out of date	• Scanning & then digitally mosaicing large aerial photos can be time consuming
2 Free LINZ orthophoto downloaded, clipped, geo-coded, & enlarged (1:10 000) by the farmer	• Freely download-able	• Possibly free • $2-$10 A3 print • $20-$50 A2 print	• Low cost • Areas & distances derived will be more accurate than using an aerial photo	• Limited coverage available • Enlargements larger than 1: 10 000 increasingly become more blurred • Requires GIS software & skills • Requires computer processing capabilities	• Programs such as Endeavour have the capacity for geo-coding • Image processing software is freely downloadable
3 LINZ orthophoto clipped, geo-coded and enlarged (1:10 000) as a paid service	• $45-$150	• Possibly free • $2-$10 A3 print • $20-$50 A2 print	• Affordable • Areas & distances derived will be more accurate than using an aerial photo • No specialist software or skills needed	• Limited coverage available • Enlargements larger than 1: 10 000 increasingly become more blurred	• Often supplied as part of a broader service
4 Aerial photo from existing commercial collections	• $45-$180	• $60-$115 A3 photo • $150-$160 A2 photo	• Affordable & readily available • Detailed collections with extensive recent coverage available (e.g. 1:27 500)	• Areas & distances derived are likely to be inaccurate • Large farms that span more than two photos tend to match poorly	• Local businesses generally have a good idea regarding what existing photography can be obtained for a given farm
5 Low altitude photo from specially flown aerial survey	• $45 (when purchased with photo) to $300	• $350-$400 for 0.5m x 0.5m photo • $130-$240 A2 photo	• Affordable • Up to date • Detailed scales available • Flight conditions can be specified (e.g. summer flight to highlight wet & dry parts of a farm)	• More expensive than obtaining a photo from existing collections • Areas & distances derived are likely to be inaccurate • Large farms that span more than two photos tend to match poorly	• Usually requires 10-15 farms before a flight will be undertaken
6 Partially rectified photo from commercial collections	• $100 - $300	• (Add $2-$10 for A3 printing) • (Add $20-$50 for A2 printing)	• Affordable • Increased distance & area accuracy *cf.* standard aerial photos	• Less accurate depiction of distance & area cf. fully ortho rectified photos • Generally only computer hardcopy print-outs are available	• Degree of accuracy is proportional to the amount of GCP used.
7 Partially rectified photo from specially flown aerial survey	• $200-$300	• (Add $2-$10 for A3 printing) • (Add $20-$50 for A2 printing)	• Reasonably affordable & detailed • Up to date and available for any farm • Increased distance & area accuracy cf. standard aerial photos (but less so than that derived from collections)	• Less accurate depiction of distance & area cf fully ortho- rectified photos • Generally only computer hardcopy print-outs are available	• Degree of accuracy is proportional to the amount of ground points used. GPS & other equipment can be used to obtain a high density of ground points
8 Orthophoto from commercial collections	• $600 • >$1000 for detailed high resolution	• (Add $2-$10 for A3 printing) • (Add $20-$50 for A2 printing)	• Accurately depict the location of objects, distances and areas • Reasonably up to date	• Expensive • Commercial collections currently have limited coverage	• The greater the quality of an orthophoto the greater the Mb image size
9 Orthophoto rectified especially for the farmer	• $500-$1000 • >$1000 if data is unavailable	• (Add $2-$10 for A3 printing) • (Add $20-$50 for A2 printing)	• Any aerial photo can be ortho-rectified • Accurately depict the location of objects, distances and areas	• Very expensive	

Table 4.4: Alternative options for obtaining aerial photos or orthophotos.

For farmers wanting the most up-to-date photography, low altitude surveys are readily ***'flown on request'*** in most areas. Resulting photos carry the advantage of high detail, and they are still reasonably affordable (around $150-$400 for an A2 size). Further, flights can be arranged so they coincide with conditions conductive to resource mapping (*e.g.* a dry summer during which dry soils can be remotely differentiated from moist soils). However, timing is dependent on obtaining a sufficient number of clients to justify a flight, and low altitude photography is particularly prone to extreme distortions caused by hilly terrain and a required wide-angle camera lens.

In situations where a greater degree of distance and area accuracy is required, any aerial photo can be scanned and processed to produce a ***partially rectified photo image***. This is still affordable at around $100-$300 (additional to the cost of the aerial photo), but the degree of accuracy achieved can be highly variable. While being more useful than an aerial photo alone, the accuracy of a partially rectified photo image still falls well-short of that attainable through orthorectification (the exception being some photos depicting flat terrain).

Commercial orthophotography at a high resolution and accuracy (excluding LINZ orthophotos) provides the most detailed and reliable mapping base for undertaking farm surveys. However, it is also the most expensive, and for many farmers it would not be a practical option. The most affordable orthophotography is derived from 1:27,500 scale photos at around $600/farm, but coverage is currently limited. Where orthophotos are unavailable, paying an organisation to process a photo is likely to cost $500-$1,000 in a best case scenario, but $2,000 or more for a worst case. However, orthophoto coverage is likely to increase rapidly over the next several years, and competition between different organisations suggests that affordability may also improve.

4.7.4.1.2 Alternative options for farm resource surveys

Five options for surveying land resources include: farmer survey; assisted farmer survey as part of a group; contracted survey; council survey; and research surveys (Table 4.5). Four options resulting in paddock maps include: farmer aerial photo interpretation (API); farmer GPS survey; contracted API; and contracted GPS survey.

It is entirely feasible that a farmer can undertake a quality survey of his or her farm resources. This would be the cheapest option in monetary terms, but the end quality would depend on the length of time and effort a given farmer would be prepared to invest in self-training and in-the-field survey. As the amount of time and level of commitment would be considerable (relative to existing farm management tasks and responsibilities), it is unlikely that this would be a practical option for the majority of farmers. Farmer surveys can carry the benefit of high ownership and personal reward, and it is likely that any resulting LR information will be well understood.

Some farmers may be able to link into farmer-focused survey training programmes, such as Soils Underpinning Business Success (SUBS). This particular programme uses a group approach to spread the cost of professional training (for soil survey), and carries a number of benefits relating to the quality, understanding, and overall affordability of any resulting LR information (Chapter 7). A farmer could expect to pay between $250 to $350 for inclusion in such a programme.

A contracted land-resource survey undertaken by an experienced and qualified professional is likely to result in the most reliable LR information, but the cost can represent a significant investment, and the resulting information will need to be interpreted by the farmer before it can be used effectively (which may involve a degree of farmer study). Estimates for hill country land-inventory survey range from $550 to $2000, while a conventional soil survey may cost between $2500 to $10,000 (depending on the required level of survey intensity and information detail, quality, and scope). As these prices are for complete service packages (including a base map, survey & final maps), the cost of survey alone is estimated at around $300-$800 for land inventory survey, and $2000-$5000 for detailed soil survey.

	Alternative options	Estimated cost	Advantages	Disadvantages	Other comments
1	Farmer soil survey (or LUC/LRI survey)	• Farmer's time	• Considerable cost savings • Greater understanding of soil and land potentials (*cf.* contracted surveys) • Personally rewarding	• High time commitment • Likely need to up-skill in soil (or LRI/LUC) survey procedures • Survey quality depends time input and farmer skill	• Farmer soil surveys are a possible scenario, but unlikely due to unavailability of non-scientific soil survey manuals • Some regional councils occasionally organise LUC/LRI training days (for new council staff)
2	Assisted farmer soil survey (group)	• $250-$350/ farmer for 10 farmers	• Affordable • Personally rewarding • Requires attaining certain survey quality standards • Group support	• High time commitment • Need to up-skill in soil survey procedures	• Possibly unviable outside a group setting – it would be cheaper just to undertake a contracted survey
3	Contracted LR survey (high level of detail & purity)	• $300-$800 for land inventory survey • $2000 to $5000 for soil survey	• Professional survey results • Low or nil time commitment	• Can be expensive • Low personal reward • Survey results need to be interpreted by the farmer – less likely to gain the level of understanding achievable through options 1 & 2	• Survey costs are difficult to estimate because they are usually included in a complete farm mapping package (inc. base map, surveying, & final map preparation)
4	Council LUC/LRI survey	• $0 to $500	• Free or low cost • Professional survey results • Low time commitment	• Usually lack the detail required for production farm management purposes • Likely to be orientated toward soil conservation • Allowing a council officer onto the farm	• Cost depends on the regional council • Such surveys are undertaken as part of broader council objectives (e.g. erosion control) • It is no longer common practice to record Land Resource Inventory during mapping
5	Farm research surveys (inc. student surveys)	• Possibly free • May involve farmer input	• Free or low financial outlay • Professional or near professional survey results • Potentially comprehensive surveys • Potentially includes other free services & resources	• Very infrequently undertaken • May involve permitting a student or researcher access to farm business records	• A full research farm evaluation can potentially include free farm photos, survey & map preparation, & an economic evaluation of current & potential farm performance
6	Farmer GPS survey (±1m accuracy)	• Hire of survey gear ($300)	• High accuracy at generally low or medium cost	• Can be expensive (e.g. hiring GPS @ $300/day) • Use of GPS equipment requires the learning of new skills • GIS software is required to make use of GPS data	• Measuring fence line extents is also easily achievable using a measuring wheel • GPS points can be used to rectify photography (and can be used on successive aerial photos in the future)
7	Farmer aerial photo interpretation	• Nil	• Quick & low cost	• Distances & areas are likely to be distorted on an un-rectified aerial photo • Can be difficult to distinguish fences occasionally • Requires digitising before areas can be measured	• Usually undertaken in collaboration with a service agency • Using orthophotos increases the potential for more accurate paddock areas
8	Contracted GPS survey (±1m accuracy)	• $250-$500 or • $25-$35/hr	• High accuracy • Professional survey results • Complete package (no need for specialist skills & software)	• Reasonably expensive • Resulting paddock map will not align with fence lines on an aerial photo or a partially rectified photo (unless the terrain is flat)	• Accuracy greater than ±1m is not generally needed for most farm management purposes
9	Contracted aerial photo interpretation	• $250-$500	• Quick • Professional results	• Reasonably expensive	

Table 4.5: Alternative options for farm resource surveys.

An alternative option to contracted land-inventory survey is having an *environmental farm plan* prepared by a regional authority. Such plans have been traditionally based on a land-inventory survey using the Land Resource Inventory and Land Use Capability Classification system (Chapter 5). They are usually undertaken as a free service (or at a nominal rate of $300-$500 for particularly comprehensive farm plans) by professional land-resource surveyors. Many will also generate a paddock map, and some will examine and report on soils in detail. However, environmental farm plans can be limited in the amount of LR information they provide; the information collected can be biased towards council objectives; it is uncertain how many councils still provide a farm planning service; and an environmental farm plan implies a long-term commitment from the farmer towards environmental management (see Chapters 5&6). However, they do represent a free (or low cost) and professional survey service.

Perhaps the best low-cost option for farm survey is through research. While being rare, a survey undertaken by a student or research organisation carries multiple benefits, such as the inclusion of a free base-map, a professional (or semi-professional) survey and final map, and perhaps even an evaluation of present and potential land use performance (*i.e.* a land evaluation). There are few limitations, other than the exposing and investigative nature of research. However, as farm research surveys are only rarely undertaken, it is unlikely that this would be a practical option for most farmers.

Aerial photo interpretation (API) and GPS survey can be undertaken by either a farmer or contractor to produce paddock maps. API is the conventional method of generating such maps, and is often undertaken by a contractor in collaboration with the farmer concerned. This is generally quick, easy and cheap, but the reliability of any resulting information is dependent upon distortions contained in the aerial photo base. Partial rectification can correct camera distortion for flat terrain (*e.g.* 1st & 2nd order polynomial transformation), but cannot generally account for relief distortion caused by hilly terrain. While orthorectification can be used, the prior generation of orthophotos to produce a paddock map is getting into the realms of high-end GIS services (*e.g.* photogrammetry), and it is unlikely that farmers could practically afford such an option.

GPS survey is perhaps the most effective and efficient method of generating paddock maps with a high degree of accuracy ($\pm$1m), and carries the added benefit of measuring elevation (if necessary). It is possible for a farmer to hire a $\pm$1m accuracy GPS for undertaking a paddock survey ($300 per day), provided he or she is prepared to learn how to use the equipment, and has the capability to translate survey data into a paddock map. Alternatively, these technical factors can be ignored if a contracted GPS survey is undertaken, and the additional cost does not appear to be significantly higher than hiring a GPS (contracted GPS survey ≈ $250-$500/farm).

4.7.4.1.3 Alternative options for final map preparation

Broad options for final map preparation include a simple drawn map; farmer prepared digital maps using either GIS or non-GIS graphics software; and paying for a commercial digitising service (Table 4.6). Tidily draughting a map from a draft survey map is the cheap, quick and easy option, but may be limited by presentation quality; the difficulty of regular updates (*cf.* computer generated maps); and they cannot be readily used to take advantage of farm management software capabilities.

Low cost high-quality and readily updateable maps can be produced by a farmer using either graphics software; some farm management software (*e.g.* Endeavour); or a GIS. Many farmers are likely to own basic graphics software (*e.g.* Microsoft Paint, drawing functions in Microsoft Word & Excel) and farm management/mapping software, and therefore have the tools needed to create computer generated maps (with area and distance information). Likewise, the Map Maker Gratis GIS software is freely downloadable, and can be readily used to create cartographic quality maps and farm-particular Land Information Systems.

Contracted digitising services are likely to use more powerful GIS, survey, and/or cartographic software applications, and should therefore result in high quality maps. Costs for commercial digitising vary according to farm type (it costs more to digitise fence lines in hilly terrain *cf.* flat terrain), and whether or not the service involves direct transfer digitising, or translation digitising. The latter involves the translation of features mapped on an uncorrected aerial photo, across onto a different photo or orthophoto. This can be a time consuming exercise (*cf.* direct transfer digitising) because features may not match (due to distortion), and photos/images captured at different times of day and season tend to exhibit variation in the shading and distinctness of landscape features and objects.

	Alternative options	Estimated costs	Advantages	Disadvantages	Other comments
1	Drawn maps	▪ Nil	▪ Low cost ▪ Quick ▪ No special technical skills required	▪ Low presentation quality ▪ Difficult to calculate accurate areas and distances ▪ Can be difficult to update ▪ Can't be used to take advantage of farm management software	▪ Quality maps require a degree of artistic aptitude
2	Farmer prepared maps using non-GIS graphics software	▪ Nil	▪ Low cost (if the farmer already has relevant software) ▪ Professional quality results possible ▪ Easy to update	▪ May not be able to calculate areas & distances (e.g. basic graphics software) ▪ Cannot generally overlay or merge different maps (e.g. paddocks over soils) ▪ Cannot perform spatial analysis processing	▪ Includes programs such as Endeavor, FarmTracker, etc ▪ Also includes software with basic graphics capabilities (e.g. MS Paint, Excel, etc.) ▪ Some higher-end graphics applications have the capacity to calculate area & overlay or merge different maps
3	Farmer prepared maps using GIS software	▪ Nil	▪ Low cost (using freeware or shareware) ▪ Readily calculate area & distances ▪ Professional quality results ▪ Easy to update & readily linked to attribute database ▪ Final map can be partially rectified (if taken from an aerial photo)	▪ Dependent on being able to obtain & use a GIS ▪ Most GIS software is very expensive & technical ▪ GIS files are not compatible with many NZ farm management applications	▪ Presently an unlikely scenario with the very high cost of GIS & need to upskill ▪ Various quality GISs (with digitising capability) are freely downloadable
4	Contract digitising service (paying someone to digitise a drawn map)	▪ \$150-\$300	▪ Relatively low cost (see option 5) ▪ Areas usually calculated as part of the service ▪ Final map can be partially rectified (if taken from an aerial photo)	▪ GIS files are not compatible with many common farm management or graphics applications	▪ Cost depends on the number of paddocks and the type of terrain
5	Translation digitising service (taking a map drawn on an photo & digitising it onto an a different aerial or ortho photo	▪ \$300-\$500	• Areas usually calculated as part of the service ▪ Final map can be partially rectified (if taken from an aerial photo)	▪ Relatively more expensive ▪ Not compatible with many common farm management or graphics applications	• Cost depends on the number of paddocks and the type of terrain

Table 4.6: Alternative options for final map preparation.

4.7.4.2 Best option scenarios

Three 'best option' scenarios have been designed according to an increasing tier of cost, quality, and farmer input. Each is based on a hypothetical hill country farm with an extent that readily fits on a single A2 sized aerial photo at a 1:10,000 to 1:20,000 scale. Farm resource-survey involves an assessment of physical resources (resulting in a paddock map) and land resources (as either soil or land-inventory survey). Final maps must provide area and distance information. Cost ranges are 'best estimates' derived collectively from the results of Section 4.7.3 (the lowest cost represents a best case scenario, and the highest cost represents a worst case scenario). Printing estimates have been taken from commercial rates charged by two commercial desktop publishers. Costs are particular to the 2001 year only. These scenarios were originally constructed to identify 'best options' for obtaining base LR information for a pilot quality assurance programme.

4.7.4.2.1 The Canny Option

Description

- Farmer uses a copy of an existing farm photo or downloads an appropriate LINZ orthophoto.
- Base map preparation undertaken by the farmer using his or her own equipment, and existing or freely downloadable software. Includes geo-referencing but not rectification.
- Land inventory survey undertaken by farmer independently. Paddock map derived from aerial photo interpretation.
- Final map preparation and output undertaken by the farmer using existing or freely obtainable software and equipment.

Likely results

- An adequate and useable base-map for survey work, and a corresponding image for use in computer applications.
- Possibly a low to medium quality survey, offset by a greater understanding of land behaviour and potentials (*cf.* professional survey & subsequent extension).
- Area and distance information – greater accuracy if a LINZ orthophoto is used, less if an unrectified aerial photo is used.
- A land resource map and a paddock map that can be used with a moderate degree of confidence for farm management purposes.

Financial cost

- No financial outlay.

Related alternatives or variations

- Obtaining an aerial photo from a commercial collection @ $150-$160.
- Obtaining a specially flown farm photo @ $230-$350.
- Inclusion in a soil survey training programme @ $250-$350.
- Council land inventory survey @ $0-$500.
- High quality and large format printing @ $20-$50/A2 print.
- Partial image rectification of aerial photo for greater confidence in area and distance information (@ $100-300/photo).
- Commercial digitising for final maps @ $75-$150 per map.

Notes

- A very cheap option, but dependent on the farmer having the equipment, ability and time needed for such an exercise.
- Quality of the final results is dependent on farmer ability and willingness to invest a considerable amount of time in learning new skills and the mapping process itself. In most cases the results are likely to be unprofessional (by definition), which has implications for using the information confidently in farm management, or for the credibility of the information when it is used to explain or justify a land use decision.

4.7.4.2.2 *The Semi-Professional Option*

Description

- A2 sized aerial photo enlargement from a commercial collection.
- Preparation of base-map undertaken by service provider. Involves two A2 sized photocopies and scanning.
- Council land inventory survey or inclusion in a soil survey training programme.
- Paddock map prepared by aerial photo interpretation (by the farmer) and digitised commercially.
- Final map preparation by a service provider (including partial rectification of the aerial photo or translation-digitising onto a LINZ orthophoto).

Likely results

- A detailed A2 sized base-map clearly showing fence lines.
- Professional land-inventory survey (by a regional authority) or possibly a medium to high quality soil survey underpinned by professional training and assistance.
- A professional paddock map.
- Area and distance information – greater accuracy if a LINZ orthophoto is used, less if a rectified aerial photo is used.
- A land resource map and a paddock map that can be used with a moderate to high degree of confidence for farm management purposes.

Estimated financial costs

• A2 aerial photo...	$150-$160	
• Photocopy (x2 A2)...	$8-$30	
• Assisted soil survey or...	$250-$350	
• Council land-inventory survey...	$0-$500	
• Partial rectification + digitising of x2 maps...	$150-$300	
• Translation digitising onto LINZ orthophoto...	$300-$500	
• Commercial A2 prints of final maps (x2)...	$40-$100	
	Best estimate	$748-$1290

Related alternatives or variations

- Obtaining a specially flown farm photo @ $230-$350.
- Obtaining an orthophoto from an existing collection @ $600.
- Contracted soil survey @ $2000-$5000.

Notes

- This option is affordable for both a best case ($750) and a worst case scenario ($1300).
- Professional or semi-professional results – high confidence in paddock map accuracy and land-resource map purity.

4.7.4.2.3 *The High-End Professional Option*

Description

- High resolution orthophoto from existing commercial collection, or orthorectification of an existing aerial photo.
- Base map prepared by service provider, including high quality printout at A2 size, and geo-referenced orthophoto image on CD-ROM.
- Contracted soil survey.
- Contracted GPS survey.
- Final map preparation and output undertaken by a service provider.

Likely results	• A detailed base map of high quality and accuracy. • Professional paddock map with high positional accuracy of +/-1m (and therefore reliable area & distance information). • Professional soil map with high credibility and reliability. • A land resource map and a paddock map that can be used with a high degree of confidence for farm management purposes.

Estimated financial costs	• Existing orthophoto (0.4m res. & +/-10m acc.) or...	$600	
	• Orthorectification service...	$500-$1000	
	• GPS survey (+/-1m acc.)...	$250-$500	
	• Contracted soil survey...	$2000-$5000	
	• Base map printouts (x2 A2)...	$40-$100	
	• Digitising & GIS processing...	$300-$500	
	• Commercial A2 map prints (x2)...	$40-$100	
		Best estimate	$3130-$7200

Related alternatives or variations	• Detailed attribute measures for key soil types.
Notes	• Best and worst case estimates ($3130 and $7200 respectively) both represent significant investments. The difference between the two estimates is also significant, suggesting it would be worthwhile to investigate the availability and costs of both survey resources and services. • Coverage of orthophoto collections is likely to increase rapidly in the next several years. GPS survey may also become more commonplace. • Resulting maps are likely to be of a very high professional standard, and can therefore be used reliably in farm management and planning, and credibly to explain or justify land use decisions.

4.7.4.3 Summary & Discussion

It is entirely feasible that a farmer may undertake a land resource survey and prepare farm maps without professional assistance. The result is likely to be a paddock map and land-resource map that can be used with a moderate degree of confidence for farm management purposes. Financial outlay would be minimal, and in doing the work themselves, farmers ***may*** gain an insight into land behaviour and land-use potential that is greater and more practical than the level of understanding afforded through a contracted survey (*i.e.* the contractor would have to explain the information, and/or the farmer would need to interpret the new and possibly technical information). An additional benefit is that farmers would also be learning new and transferable skills.

However, effective application of this scenario would depend on the farmer having the time, resources, ability and inclination to collectively undertake self-training, farm surveys, and final map preparation. As a general statement, farmers are perhaps too busy with other commitments for this option to be practically feasible. Also, because the resulting information has not been generated by a professional, it may carry less credibility if it is used to explain or justify land use decisions to outside interests.

Credibility and potential quality is improved with the second scenario. Costs are reasonable (S750 to S1300 for a best and worst case scenario), with the result being a professionally prepared paddock map, and either a professional land-inventory map (through a regional authority) or a semi-professional farm soil map (farmer prepared map under the guidance and support of a professional soil surveyor). The paddock map may be of reasonable quality, limited only by the clarity of LINZ orthophotos (it can be difficult to discern where some fence lines are located) or the degree of rectification applied to an aerial photo. However, LINZ orthophotos, regional council survey services, and assisted soil-mapping programmes may not be available to some farmers (thereby necessitating the use of an aerial photo and/or contracted land-resource survey). Hence, although being an affordable scenario that is likely to result in credible and reliable LR information, it may not be practically feasible for all farmers.

The most expensive scenario is based completely on professional services with little farmer input. The advantages include very high quality maps that can be used reliably and credibly for the functions of LR information (*e.g.* decision-making, planning, communication, justification of a land use decision, etc.). However, the estimated cost represents a significant investment (S3100-S7200) that many farmers may be unwilling to make. Further, because a farmer would not be directly involved in the land-resource survey, effective use of the resulting information will depend on the communication skills of both the contractor (in an extension sense) and the farmer (in an interpretation sense). Despite the high potential quality of LR information resulting from this scenario, the cost is likely to prohibit most farmers from considering it as being a feasible option.

None of the three scenarios consider the possibility of 'package deals', whereby a business or consultant may be prepared to lower the cost for a complete and combined mapping service (costs used for the three scenarios are standalone estimates).

CONCLUSIONS

Objective 1: Qualitatively evaluate which sources of published and readily obtainable LR information have a likely utility towards pastoral farming in terms of information relevance and reliability.

- Twelve sources of published & readily available LR information were qualitatively evaluated against predefined criteria. Criteria included geographical coverage; method of collection; information type; scale; reliability (accuracy, variability, purity, observation density, and scientific rigour); accessibility; strengths & limitations; and overall relevance towards farm planning & management decision-making.
- All twelve sources of LR information were considered to have a low potential utility towards farm planning & decision-making, primarily because of limited geographical coverage and inappropriate scales. Sources available at farm or paddock scales tend to have limited geographical coverage, while those with extensive coverage tend to be presented at scales inappropriate for farm management purposes (*i.e.* scales less detailed than 1:20,000 to 1:30,000).
- Reliable and relevant LR information for individual farms at appropriate scales, cannot – in general – be sourced from public map collections and databases. Farmers interested in using LR information for farm management purposes can only do so if they collect new information.

Objective 2: Identify the types of survey tools, resources and services commercially available to farmers interested in obtaining new LR information.

- Types & costs of survey tools & services commercially available from nine organisations were identified through phone interviews. An insight into the type & cost of commercial land-resource surveys (at different levels of quality) was obtained from three consultants through mail survey.
- Aerial photography enlarged to farm management scales is readily available from national collections at a reasonable cost (≈$200/farm photo). If very up-to-date photography is required, low altitude surveys may be undertaken by some businesses more-or-less on request (≈$130-$400/farm photo).
- LINZ orthophotos (2.5m res. & ±12.5m acc.) are freely available for 55% of NZ's land area, and coverage is increasing at an average rate of 9% per year. These are generally suitable for farm management & surveys, although they may lack clarity for detailed purposes. Coverage of higher-quality rural orthophotography (e.g. 0.4m res. & ±10m acc.) is limited and expensive (e.g. $600/farm image). Four of the businesses are capable of undertaking orthorectification on request ($600-$1000/farm image).
- Most of the businesses are capable of preparing farm maps as a service for farmers (maps of land resources, paddocks, landscape features such as aspect, elevation, slope, etc.), but not all would be willing to do so (farmers are not their targeted clientele). Likewise, most businesses were capable of providing a digitising service at around $50-$60/hr or $250-$500/farm.
- Commercial services for land-inventory type surveys are available at affordable costs ($270, $540, $1080 and $2160 for four levels of quality). Services for conventional soil survey are likely to be considerably more expensive, with one consultant providing estimates of $2500, $6500 and $10,000 for three levels of quality.
- A wide variety of commercial services and survey resources are available to farmers interested in obtaining new LR information. Price and quality varies, so it is in the best interest of farmers to assess alternatives before making an investment.

Objective 3: Determine alternative 'best option' combinations available to pastoral farmers interested in obtaining new LR information.

- Alternative options for: obtaining a survey base-map (an aerial photo or orthophoto); undertaking a land-resource survey; and for preparing final maps, were used as a basis to design and evaluate (in terms of cost, advantages & disadvantages) three scenarios for obtaining new LR information (as a land resource map & paddock map) for an hypothetical hill-country farm.
- It is possible that a farmer could undertake an LR information collection exercise by using existing or freely-obtainable survey resources without specialist input. While the farmer may gain considerable knowledge (*cf.* gaining just information), the resulting LR information is likely to vary in terms of quality, and may have limited credibility to outside interests (because it is not generated by a specialist). Likewise, while any financial outlay would be negligible, an effective application would require a high investment of time in self-training, survey, and map production. Farmers are perhaps too busy with other commitments for this scenario to be practically feasible.
- The most expensive scenario is based on high quality survey resources (*e.g.* detailed orthophotography), technical services from specialists (*e.g.* GPS survey), and limited farmer input. While information quality and credibility is likely to be very high, a financial investment of \$3100-\$7200 may be too excessive for most farmers. Further, effective use of the information for farm management purposes would depend on the communication and extension skills of the parties involved.
- An affordable scenario resulting in credible information of a quality standard, involves a balance between input from a commercial specialist and a farmer. A professional paddock map, and either a semi-professional soil map (farmer prepared under the guidance of a specialist soil surveyor) or professional land inventory map (through a regional authority), can be prepared for between \$750-\$1300. However, the feasibility of this scenario is dependent on the availability of survey training programmes, and whether or not a given regional authority will provide land-inventory survey as a service.

The original aim of this study was to qualify the value of LR information sources and services for pastoral farm decision-making. As a general statement, farmers cannot obtain reliable and relevant LR information from existing sources because such information does not exist at a scale suitable for farm management purposes. The most feasible and affordable option for collecting new LR information appears to be a scenario based on a dual investment of farmer time and finances (for quality survey resources and specialist input). Farm-particular LR information generated from both farmer & specialist input is likely to be affordable, credible, and of a standard suitable for use in farm management decision-making.

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