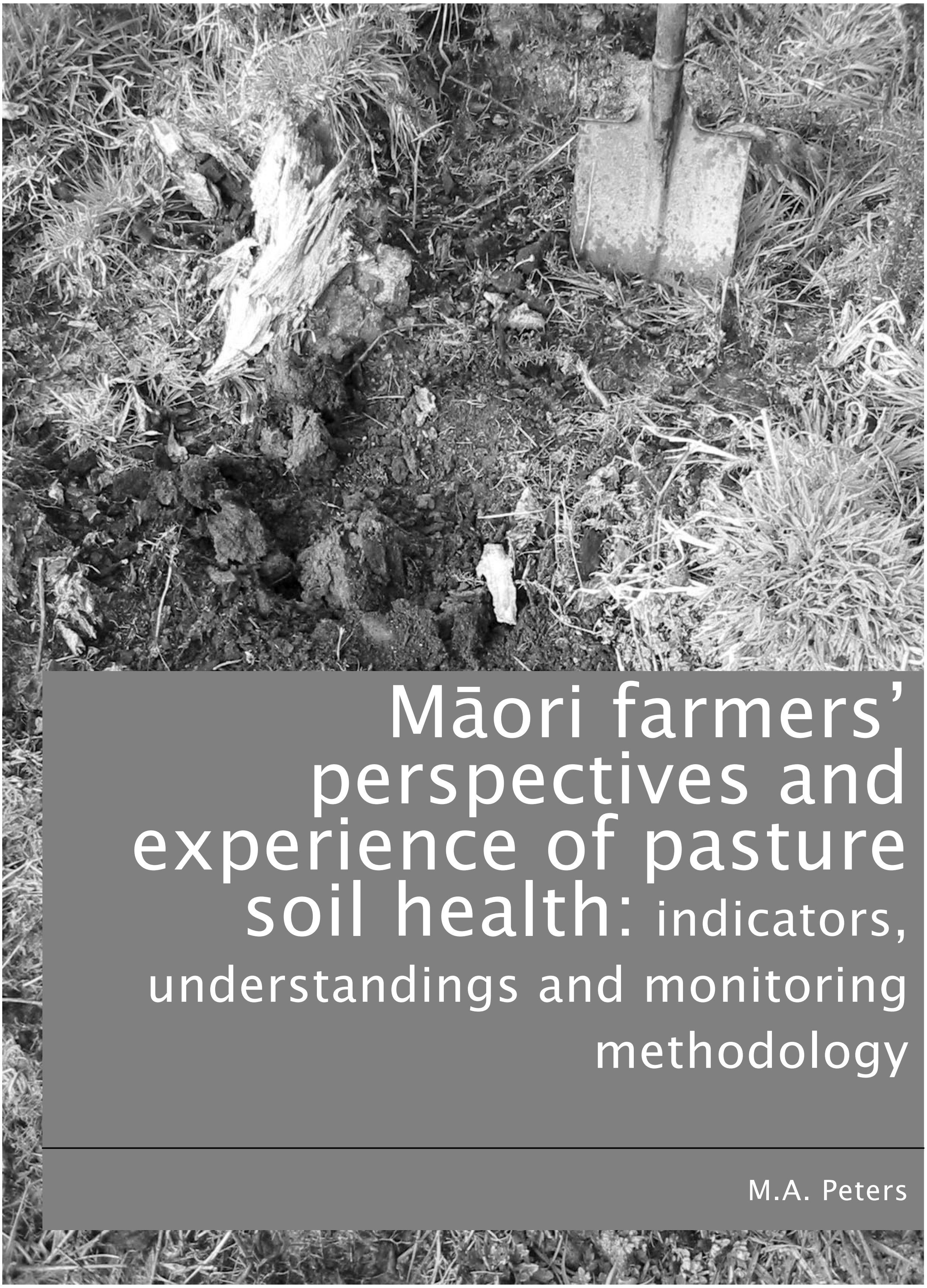

Māori farmers' perspectives and experience of pasture soil health: indicators, understandings and monitoring methodology

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Māori farmers' perspectives and experience of pasture soil health: indicators, understandings and monitoring methodology

Case studies in the southern South Island of New Zealand

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EXECUTIVE SUMMARY

Soil forms the literal foundation of the agricultural industry. As a bio-physical property as well as social construct, soil quality can be approached, analysed and understood from multiple directions. This study investigates soil quality, how it is described, which key indicators are used, monitoring methods and ways in which soil knowledge is gained through the experiences of 8 Māori pastoral farmers located in the southern South Island of New Zealand. As the maintenance of soil quality / health is integral to maintaining both farm socio-economic viability as well as cultural and spiritual health for Māori, engaging in dialog with Māori farmers is needed in order to facilitate a broader, more inclusive understanding of how the soil resource is understood in terms of both its productive and intrinsic values. The broader context for this study is the tension that exists between local knowledge and scientific knowledge. The basis of this tension lies in the fact that farmers and scientists describe and measure soil health using different languages. Their methods differ, just as their tools do. Understanding the key indicators used by farmers in their daily and seasonal routines serves as useful starting point for developing a dialog based on the shared understandings between farmers and researchers both in terms of the terminology used and the priorities of each. Additionally, understanding the information sources most trusted by farmers as well as the ways in which new knowledge evolves on farm can provide stepping-stones for future collaborative initiatives which seek to integrate knowledges. Farmer methods of monitoring the condition of their soil resource emerge as a key consideration given the mounting pressure for accountability from both internal and external markets. The rapid pace of technological and social change within the agricultural sector greatly strengthens the need for an integrated base of knowledges to address issues of soil degradation and to design pathways toward sustainable systems. The scope and limitations of these seemingly disparate forms of knowledge can be illuminated through examining both the temporal and spatial scales each operates within. Clarifying similarity and difference facilitates not only possible knowledge integration, but also paves the way for mutually beneficial collaborations between cultures. Given the emphasis on culture in this study, codes of conduct were drawn from Maori protocol were used to underpin and guide the interviews. Critical reflections on the methods used are rarely detailed in the literature therefore to underscore the function of research as a learning process, self-reflection on methodology is included to inform other researchers navigating similar transcultural terrain.

Key words: Soil quality, Maori, pastoral agriculture, indicators, local knowledge, scientific knowledge, soil quality monitoring

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Firstly, a heartfelt thanks to the research participants for their warmth, humour and generosity. The information freely shared by the farmers over the course of this research allowed me an insight into parts of this country and the lives of the people that live that I would otherwise never have had the opportunity to see or experience.

A big thanks to my supervisors, Dr. Henrik Moller for technical details as well as keeping me on track over the course of the year and Dr. Jim Williams for patient and much needed cultural advice. I set out to learn a lot through undertaking this thesis, and did. Thanks also to John Reid (He Whenua Whakatipu), whose (initially baffling) advice “Don’t assume that you are any different to [Māori] but don’t assume that you are the same” proved thought provoking and in the end, invaluable by sharpening my awareness of possible inadvertent assumptions made about culture.

Further thanks are also due to the other members of ARGOS and He Whenua Whakatipu and the agri-consultants queried over the course of the research for valuable discussions, advice on soil analyses as well as on-ground support for fieldwork.

Last (but not at all least) many thanks to Norm Mason for unconditional moral support and much valued pragmatic advice.

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ACRONYMS

ARGOS	Agriculture Research Group on Sustainability
DSS	Decision support systems
HWW	He Whenua Whakatipu
MAF	New Zealand Ministry for Agriculture and Forestry
MfE	New Zealand Ministry for the Environment
OECD	Organisation for Economic Cooperation and Development
PCE	New Zealand Parliamentary Commissioner for the Environment
PFI	Practical Farmers of Iowa
SMS	Soil monitoring site
SQ	Soil quality / health
TOT	Transfer of technology

1 INTRODUCTION

The notion of “soil health” has evolved from concerns about agricultural impacts on natural resources (Doran and Zeiss 2000, Wander and Drinkwater 2000) and is conceptualised as a key indicator for achieving the major goal of sustainable agriculture (Herrick 2000, Doran and Zeiss 2000, Lobry de Bruyn and Abbey 2003). Soils are complex; minerals, organic compounds and living organisms continuously interact in response to natural and anthropogenic chemical, biological and physical forces (Allen *et al.* 1995). Soils are multifunctional, providing an extensive range of ecosystem services through their capacity to conduct and store water; fix and release nutrients; absorb or degrade toxins and pathogens; modify water quality and support biodiversity (Hewitt 1999). More specifically at paddock level, soil condition directly influences pasture production and therefore pasture utilization and stock-carrying capacity (Shepherd and Park 2003). Economically, agriculture forms one of New Zealand’s most important industries, and combined with horticulture, covers an estimated 64% of the country’s total land area (TPK 2002: 22). The use of the term “underground economy” therefore describes the strategic role of soil as the literal as well as metaphorical foundation for industry (PCE 2004a).

The agricultural sector in New Zealand, is dominated by livestock production systems, namely dairy cattle, beef cattle and sheep, all of which are based on grazed pastures (Matthews *et al.* 2002a). There are however, considerable risks associated with pastoral agriculture: erosion and compaction, contamination and the loss of organic matter all contribute to a loss in soil quality (Bloomer 2002, PCE 2004a: 26). Effective management practices by contrast, may lead to the stabilization or even improvement of soil ecosystem functions over time (Franzluebbers 2002). A key opportunity for reversing soil degradation thus lies with the farmers or land managers themselves (Arshad and Coen 1992), yet dialogue between farming communities and researchers is still lacking, and in New Zealand is much needed in order to focus and direct research (Nimmo 2005:4).

1.1 Soil health / soil quality

The terms “soil quality” and “soil health” are often used interchangeably by the popular press and in scientific literature (Allan *et al.* 1995). Doran and Zeiss (2000) summarise the concept of soil health/ quality as the “…capacity of a soil to function as a living system to sustain biological productivity, promote environmental quality and maintain plant and animal health”. This broad definition encompasses such themes as soil fertility, potential productivity, resource sustainability and environmental quality (Singer and Ewing 2000). Defining whether a soil is of high or low quality, healthy or unhealthy, good or bad quality also rests on the perceived suitability of the soil for its intended end use, function or purpose (Sparling and Schipper 1998). A further consideration is the degree of modification a soil requires in order for it to be suited to its intended use (Cornforth 1998:209), and thus encompasses the notion of fitness for future use.

For the purposes of this study, the terms soil health and soil quality (SQ) are used synonymously. Given the key link between soil health and human well-being, determining quality/health has evolved into a dynamic field of research where “hard” and “soft” (*sensu* Kelly and Bywater 2005) sciences converge, and at times collide by virtue of their different approaches. Simultaneously a bio-physical property as well as social construct, soil quality is therefore approached, described, analysed and understood from multiple directions, as Figure 1. demonstrates.

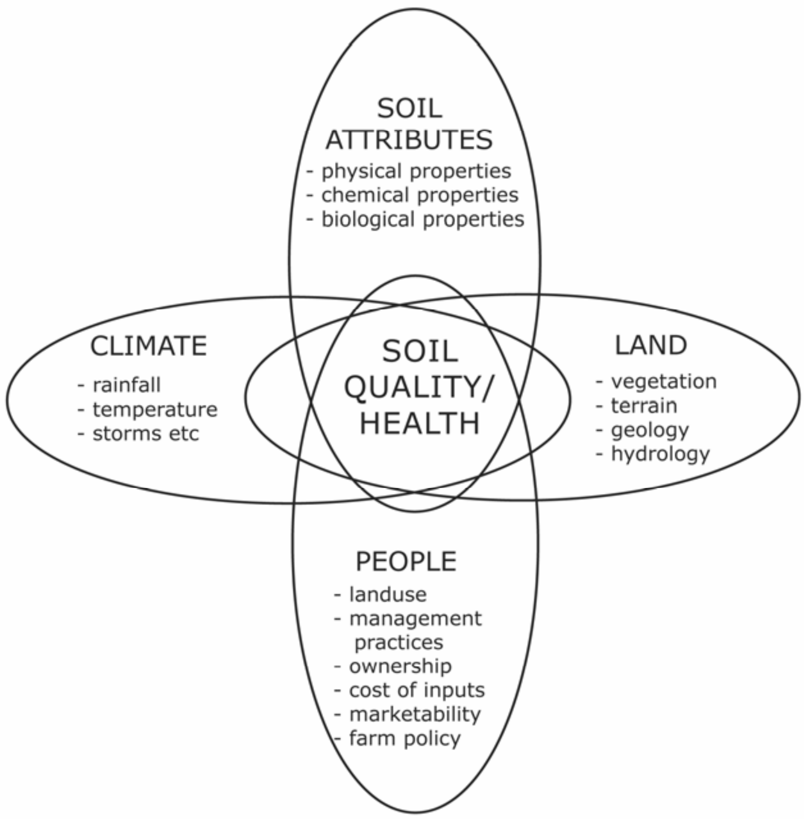

Fig 1. Factors linked directly and indirectly to the quality of the soil are numerous, complex and interdependent.

The multifaceted nature of soils, and the task of defining and measuring soil quality have generated considerable debate (see Sojka and Upchurch 1999, Letey *et al.* 2003; Sojka *et al.* 2003). Although internationally accepted scientific methods underpin soil quality related research (Karlen *et al.* 2003), a wider and more contentious arena is opened when the focus is directed at farmer knowledge and understanding of soils. The fundamental premise of farmer-based research is that farmers' localised and context specific knowledge - often resulting from many generations managing the same land, will contribute toward the evolution of sustainable agricultural systems (Pretty 1995, Sillitoe 1998, Birmingham 2003, Scoones and Thompson 1994a, Talawar and Rhoades 1998, Pawluk *et al.* 1992), yet the validity of farmers' often non-quantitative methods and SQ indicator choices are widely questioned by scientists. Sojka and Upchurch (1999) advocate that SQ should stay in the realm of edaphologists[1] by stating: "…physical, chemical and biological index components should have zero reliance on subjective perceptions". The rationale for this statement lies in the fear that a "value-laden holism" will *replace* the neutrality of conventional science. This tension between scientific knowledge and traditional or local knowledge provides the broader context for this research.

1.2 Māori and pastoral agriculture

Despite the growing body of international literature exploring the potential benefits of tapping into local soil knowledge, little research to date has been specifically directed at understanding indigenous attitudes and approaches to the soil resource and its management in New Zealand. This makes a compelling case for focusing research specifically on Māori farmers. As the maintenance of soil quality / health is integral to maintaining both farm socio-economic viability as well as cultural and spiritual health for Māori, engaging in dialog with Māori farmers is needed in order to facilitate a broader, more inclusive understanding of how the soil resource is understood in terms of both its productive and intrinsic values. Thus a strong motivation for undertaking this research is to contribute to the further development of transcultural and trans-disciplinary dialogues within the agricultural sector.

Māori, as *tangata whenua* or "local people" of New Zealand, have rights and interests in natural resources and environment which are of a distinct nature and different to those of the general public or stakeholder groups (Cooper and Brooking 2002). For Māori, *whenua* or land functions as a primary source of collective identity (Whangapirita *et al.* 2003), with the chief linkage of the individual expressed through *whakapapa* or genealogy. Although land and the natural resources derived from it are regarded as a *taonga* or treasure, land and soils forms a

[1] Edaphology is the study of the influence of soil on living things in particular plants, including man's use of land for plant growth (Lobry de Bruyn and Abbey 2003)

major also forms a major resource on which Māori derive large actual and potential economic benefits (Wedderburn *et al.* 2004). Early Māori were quick to move from traditional subsistence cropping to commercial agriculture, using the new farming methods to meet their own needs as well as to establish lively markets supplying the fledgling European colonies (Evison 1993:15, Kingi 2002). Pastoral agriculture was well established by the mid 1800s in both the North and South Islands (King 2003:416,473). From the 1870's to the 1940's, pastoralism largely replaced cropping and from 1945 onwards Māori increasingly left rural areas for urban centres (Roskruge 1999a). Since 1840, a complex history of legislation has had a profound effect on the Māori land base, significantly diminishing its extent (Wedderburn *et al.* 2004) which have undermined Maori economic development. Despite much of Māori owned land being unsuited for agriculture, currently almost two thirds of the Māori commercial asset base is concentrated in the agricultural sector[2] (TPK 2002:18,22). Today, Māori own 12% of the country's farmland and many Māori collectives own and operate successful sheep, dairy, and beef farms (NZIER 2003:24, Pikia 2004:8). As a key stakeholder in New Zealand pastoral farming, future growth in the Māori agricultural sector is predicted (NZIER 2003:24).

1.3 Research structure

This study explores and examines a subset of the numerous, complex and interdependent factors linked to SQ through using qualitative approaches. As a broadly defined concept, SQ lends itself to trans-disciplinary study by virtue of the multi-faceted nature of the resource. While quantifying soil physical, chemical and biological properties provides important baseline data on pastoral soil quality for farmers and researchers, combining these results with farmers' experiences and collective local knowledge acknowledges that "soil health" is part of a dynamic system driven by a range of social, spiritual, economic and environmental factors (Molloy 1988). The broad range of people engaged in soil-related research, which includes extensionists, rural sociologists, anthropologists, development workers and pedologists attests to the range of ways that the relationship between people and their soil can be investigated. This diversity of approach has opened a fertile critique on the choice of methods used to investigate this relationship and relative disadvantages of taking a conventional science only focus. This study, in taking a broad-brush approach to the concept of soil health therefore aims to investigate different knowledge systems as well as the ways in which they are used, particularly in relation to the transcultural emphasis of the work.

[2] There is a severe lack of both recent and reliable statistical information on Māori agricultural interests. In particular the agricultural census statistics collected by Statistics New Zealand do not differentiate between Māori and Non-Māori landowners (TPK 2002:23)

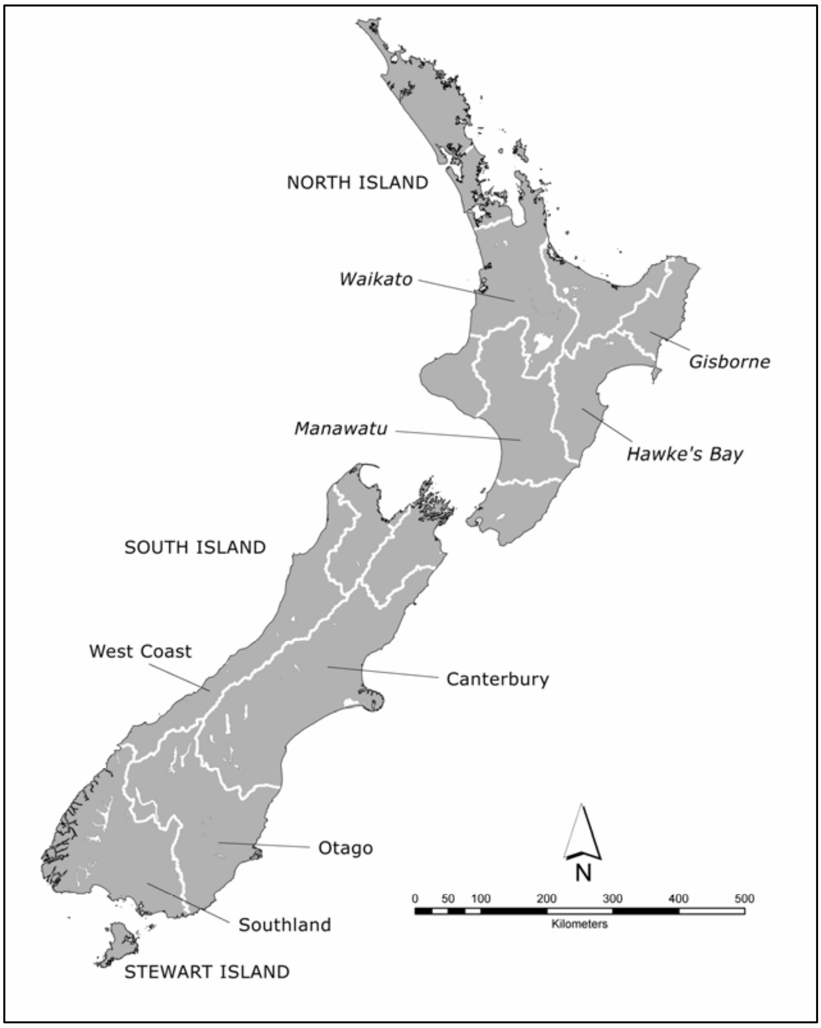

Fig. 2 Map of New Zealand showing study regions (un-italicised). Regions in italics are where other studies mentioned in the text are located.

1.3.1 Chapter outlines

This study comprises 6 main chapters followed by a general discussion linked to the previous chapters and overall conclusion. After a general introduction, an investigation into transcultural research (Chapter 2) considers the range of culturally focused criteria needed to guide studies of this nature. While methods are included in each of the chapters, a more detailed version appears in Chapter 3. This highlights the varied nature of the study participants and goes some way toward describing the range of socio-economic contexts this study takes place within.

In Chapters 4, 5 and 6, three interconnected themes have been selected recognizing that SQ is neither a static concept, nor one that can be understood in all its richness from a single strand of inquiry. Farmers' understandings of soil on a localised level within the present form the starting point of this study and is expanded to include a range of factors perceived to influence SQ on more indirect or diffuse levels.

- Chapter 4 examines the varied terms used by farmers to describe what they consider to be a healthy soil. Key indicators used to determine the condition of the soil by each of the farmers are identified in this process.
- Chapter 5 examines farmer ways of learning and the location of the farmer within a nested hierarchy of information systems (Nerbonne and Lentz 2003). Rather than ask how farmers make their management decisions, the question instead centres on how farmers learn and where information relating to soil health and overall land management comes from.
- Chapters 6 investigates farmers' formal and informal approaches to monitoring on farm SQ.

The General discussion (Chapter 7) expands the focus from farmer interview-based research to question the relationship between scientific and local knowledge systems. This is followed by a General conclusion (Chapter 8) and Recommendations for further research (Chapter 9) references and appendices.

1.4 Research links

This study is linked to He Whenua Whakatipu (HWW), which undertakes research into developing sustainable farming with Māori landowners in the Ngāi Tahu tākiwa. HWW was established to ensure the maintenance of ahi-kā on whānau land (see Appendix one for an outline of HWW). Two of the farms in the current study form the core participants of HWW. The organisation in turn forms a component of the Agriculture Research Group on Sustainability (ARGOS)[3], which comprises a trans-disciplinary team of researchers from the University of Otago, Lincoln University and Agribusiness Group Ltd. This study supports overall HWW sustainability goals through contributing in a practical way to the development of an information pool focussed on the knowledge, skills and experiences of contemporary Māori farmers.

This study plays a part in the broader HWW objective by assisting HWW farmers to both identify and find solutions for their own soil problems. The social data collected in this study will contribute to the information base on potentially useful indices for both farmer-based and specialist monitoring as well as facilitate communication between farmers, HWW and other service providers.

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[3] www.argos.org.nz

1.5 Scope and limitations

Investigating the multi-dimensionality of a topic such as soil health/quality necessitates a trade-off between the depth and breadth of the proposed research. While this can be perceived as a limitation, it however allows the researcher to expand the breadth of the study in order to examine the linkages as well as disjunctions that exist between different research methods. While the unique cultural worldview of Māori overlaid with the complex history of past legislation affecting rights to the land are clearly central to creating a solid social, political and economic context for this study, exploring these areas in detail are well beyond the scope of this study. A timeline comprising key legislation affecting Māori and land is therefore appended (Appendix three) to provide an historic overview.

Pastoral farming was selected as the farming type as it forms the backbone of agriculture in New Zealand. A factor that needed to be taken into consideration for carrying out this research centres on logistics: participants needed to be within a reasonable driving distance for interviewing face to face as well as for eventual soil sampling, hence locating the study in the lower South Island. It is also important to add that approximately 10% of the total Māori population in New Zealand (526 281 people) reside in the South Island (TPK 2002:12, 2001 census), which resulted in a small pool only of potential study participants. This in conjunction with cultural factors outlined in the following chapter on transcultural research (Chapter 2) and in the Methods section (Chapter 3) precluded the use of a strictly randomised sampling design. Yet in spite of this, the interviewees in this study represent a highly diverse group and it is this diversity that compensates for the small sample size.

2 TRANSCULTURAL RESEARCH

As was mentioned in the introduction, an objective of this study is to contribute to the knowledge base on Māori agriculture with specific reference to notions of soil health. This however raises a number of questions in relation to culture, specifically transcultural discourses as well as the methods used. Gaining a working understanding of how farmers from a different culture understand and use their environment to an outsider (i.e. as a researcher) is highly complex, and in some cases even gaining access poses challenges as knowledge is unevenly distributed within and between any society. The risk here is that not all relevant voices will be heard. "Whose knowledge counts?" (Chambers 1983, Pretty 1995, Thompson and Scoones 1994) has been a frequently asked question as in many cultures knowledge is strongly tied into variables such as social status and structure, gender, ethnicity, religion, occupation, age and education (Birmingham 1996, Grossman 2003, Thompson and Scoones 1994, Oudwater and Martin 2003).

Recent ethnopedology literature highlights the complexity of gathering socially-oriented data across cultures. Pottier (1994) for example describes how knowledge may be closely guarded and withheld from others through distrust, or through being a family secret. In some cases, understanding key issues affecting a community can be challenging. Farmers may give the highest priority not to the largest problems, but to those the farmers feel could be solved by the "outsiders" (Pasquini and Alexander 2005). Grey and Morant (2003) examining farmers' perception of soil fertility in Burkina Faso, describe how the preponderance of environmental projects granting significant material benefits to communities encouraged some farmers to exaggerate soil fertility declines.

Both Talawar and Rhoades (1998), and Neimeijer and Mazzucato (2003), underscore the need for research that that goes beyond linguistic understanding of soil health to incorporate the concepts, ideas and theories that underlie what farmers say about their soils. For this to occur, researchers require "…a leap of imagination" in order to enter the world of farmers' ideas, values, representations and performances (Scoones and Thompson 1994). Imagination requires the researcher to look *beyond* the information presented and to probe its meaning, often using frames of reference outside of those normally used by the researcher. In New Zealand, Tolich and Davidson (1999) underline the importance of first needing to understand the Māori world "…as well as the Māori ways of knowing about it". Harmsworth (2001:18) recommends further attributes needed by researchers include empathy toward Māori culture, excellent communication skills as well as some understanding of *te reo* (language) and *tikanga* (custom, lore). These understandings are critical as answers for example may be given in the form of metaphor[4] and subsequently misinterpreted (Parsons 2000). Additionally, there may be a tendency by the researcher to disregard information if it seems illogical, inconsistent or incorrect (Pasquini and Alexander 2005). In this respect, Oudwater and Martin (2003) highlight the necessity of questioning where differences and inconsistencies in local knowledge come from as the means toward generating insights into farmer perceptions.

2.1 Codes of conduct

"As researchers we need to be aware of how people are reacting to us" (Grey and Morant 2003).

In New Zealand, a damaging history of colonialism has contributed to some Māori regarding academics and researchers "…with suspicion at best, contempt in the main" (Irwin 1994:38). This history has provided fertile ground for developing culturally sensitive protocols designed to bridge gaps between Māori and non-Māori culture which can be applied to similar gaps evident between the academic and the farming worlds. Codes of ethical conduct for research with Māori have emerged in recent years as a counter toward a history of "scientific colonialism" (Cram 2002:7). While codes of conduct or "cultural safety" contracts have been designed primarily for researchers working at the *iwi* (tribal group) or community level (see Moller 1996, Taiepa *et al.* 1997, Moller 2001, Cram 2002:87, Harmsworth 2004:14), they still function as a valuable best practice model for research with individuals - as is the case in the current study. These codes and contracts also serve another purpose, namely to raise awareness of non-Māori like myself to the level of sensitivity required for negotiating the sometimes complex terrain of the "other" culture. Simultaneously, these codes clearly reveal the fundamental value structure within Māori society.

A discussion paper by Te Awekotuku (1991) centring on research ethics in Māori communities, underlines the need for honesty and self-reflection on the part of the researchers and the right of Māori research participants in receiving respect and sensitivity toward their culture. An extension of Te Awekotuku's discussion is a seven-point guide for researchers to follow (Mead 1996):

1. aroha ki te tangata (a respect for people);
2. kanohi kitea (the seen face, i.e. present yourself to people face to face);
3. titiro, whakarongo, korero (look, listen, … speak);
4. manaaki ki te tangata (share and host people, be generous);

[4] Metaphor is a form of knowledge transmission rooted in Māori oral tradition and used to express relationships between people and other things tangible and intangible (Parsons 2000).

5. kia tupato (be cautious);
6. kaua e takahia te mana o te tangata (do not trample over the mana of people);
7. kaua e mahaki (don't flaunt your knowledge)

According to Te Momo (u.d.), adhering to each of the codes in the above guide is "…crucial … in order to enhance trust in and benefit of the research process for the Māori participants". Trust is critical, and as Nerbonne and Lentz (2003) working with U.S. farmers report, opened the door for many different conversations which otherwise would not have taken place. The benefits however are not simply for the research participants alone. Being aware of these codes and integrating them into the research methodology enables a far richer level of discourse while simultaneously side-stepping the traditional boundaries separating the researcher from the researched. The implications of moving from a linear, researcher-directed approach to a more integrative and participatory form of research is described in the following way:

> "The boundaries between researcher, extensionist and farmer are being dismantled by changes in methodological practice. The researcher is no longer considered to be a detached, invisible investigator… With an interactive, dialogical approach, the researcher acts as a catalyst, a facilitator and provider of occasions, with learning occurring continuously and reflexively. In this dynamic and power-laden process, there are no neutral parties, everyone is engaged" (Scoones and Thompson 1994a).

What the codes and the excerpt above make clear is that "gathering data" ceases to be merely an act carried out by the researcher but an activity charged with a new and extended set of responsibilities. This approach provides the researcher with a strong philosophical foundation upon which to develop appropriate research methodologies. Combined with the codes of conduct, a New Zealand-specific moral framework is created in which to situate transcultural research.

3 METHODOLOGY

3.1 Theoretical framework

Grounded Theory (Glaser & Strauss, 1967) forms an appropriate research framework and method of analysis given the highly social nature of this study as well as the increasing level of “abstraction” in the 3 primary themes investigated. Instead of being segregated into distinct phases i.e. gaining access, data gathering and data processing, the research process used in Grounded Theory is instead one of continually revisiting the key themes and the sense-making processes of the research participants within the interviews. This approach, both iterative and evolutionary by nature, is analogous to Bishop’s (1996: 33-34) interviews with Māori where the discourse “spirals” as meanings are constructed and re-constructed until their final form is reached.

Rather than testing *a priori* hypotheses, the Grounded Theory method instead is one of constant comparison both within and between the primary data – in this case interviews, field notes and observations – as well as with relevant literature. As the researcher enters the field “…with a particular sociological perspective and with a focus, a general question, or a problem in mind…” theories are generated from, and “grounded” within the data (Glaser and Strauss 1967:33). The research process is essentially inductive and interpretative, allowing ideas to evolve and be explored without the constraints imposed by prescriptive theory. The analysis and interpretation of the raw data produced involves an iterative, cyclical process of coding from which categories emerge. These categories and their properties are constructed both by the researcher and from the raw data itself. Hypotheses and concepts are thus generated from the data and not only come from the data, but are systematically worked out in relation to the data during the course of the research. The primary focus of the research is theory development and ultimately verification through meaningfully relevant theory (Glaser & Strauss, 1967).

3.1.1 Study participants

This study evolved through contact with farmers participating in the He Whenua Whakatipu Sustainable Development (HWW) Programme. Further study participants outside of these programmes were contacted primarily by word-of-mouth, using informal networks established through the previous research programmes undertaken at the University of Otago as well as through the Southland Regional Council (EnviroSouth). Using existing contacts is an effective and rapid method for establishing contact with potential study participants, particularly given the historical factors outlined in Chapter 2.

To maintain confidentiality, individual farmers are referred as F1, F2….F8. A demographic summary of the study participants can be found in Appendix four. This study covers a wide range not only of locality and associated variables such as climate and soil type, but the farmers themselves also range widely in other factors such as years of farm experience, generations on the land, education and age. It must be emphasized that while this study focuses on a single cultural group and on a specific type of farming, the study participants are extremely heterogeneous. Providing a brief narrative into what the backgrounds of the participants are reveals one facet of the socio-cultural complexities inherent within so-called "groups" of people.

All but one of the 8 interviewees come from farming families and of these, 5 have stayed on or close to the family farm/ family land. One farmer is female and the rest are male. The nature of land tenure differs among participants and ranges from owner/operator (4 farmers), employee (1 farmer) to lessees of multiply owned blocks of Māori land containing some freehold acreage (3 farmers). Three of the farmers have moved to a different part of country, either to purchase a farm and/or be employed on another farm. Half of the farmers describe the farms they were brought up on as either, "not really well geared up" (F5) or as a "hobby farm" (F1), thus the focus on improving farm productivity represents a relatively recent move for some. Consequently, each of the properties is at a different stage of development – as one farmer put it: "You don't have to be Einstein to see that [this] land needs a digger, 'dozer and diesel" (F2). Somewhat surprisingly given the number of participants in this study, the level of farm operation ranges across the full spectrum of intensity, from extremely low / almost no input, through to high intensity, high input dairy farming. The latter end is neatly summarised by a farm manager as being "churn-and-burn, mate" (F7). Pastoral agriculture therefore means differing things to each the farmers in this study – from representing a form of employment, to a way of life, to a means toward deriving an income from and thus retaining blood ties to family land.

3.1.2 Cultural identification

An issue of considerable importance encountered in the course of this study centres on cultural identification. As study participants were selected through existing networks, participants were in effect identified as Māori by an external source. However, all but one of the participants self-identified as Māori: for most culture was a source of pride. In the remaining case, as the interview progressed it became clear that raising the topic culture would have been inappropriate. This creates a potential dilemma for the researcher, as it is not clear whether under different circumstances, such as in an interview without the presence of for example, a non-Māori spouse, conversations would have unfolded differently. In this instance it was decided to include the farmer in the study, as it was felt that the farmers' knowledge, views and experiences would contribute to the development of themes this study is built upon.

3.1.3 Consultation

Andrews *et al.* (2003) underline the importance of extensive consultations with a range of specialists such as sociologists as the minimum requirement for on-farm research. In the current study, consultations (which included discussions with a cultural advisor both pre- and post interview) enabled questions to be better framed in light of which information did – and *didn't* - arise from conversations. Open-ended questions, for example, regarding cultural relationships to the land needed to be asked in different ways to respect the complex and differing nature of this relationship to individual farmers. Due to the close family-oriented nature of the research the issue of who to talk to, in other words, who had the authority to be the "spokesperson", was not raised.

3.1.4 Interviews with farmers: considerations

Interviews comprised a fluid mixture of open and closed questions. Open-ended questions allowed a free-flow of ideas to be generated without restricting participants to a limited direction of enquiry – such as when investigating more subtle and complex process-oriented themes such as farmer learning. The use of a standardised set of question in this instance would not have yielded the richly worded narratives given by some participants, an important point also raised by Birmingham (1996) whose own study contrasts SQ-related responses given by two different tribal groups in Africa. Geertz (1993) describes this type of response as a "thick" description, where information extends far beyond a simple answer, instead becoming a narrative bound by individual context. "Thick" descriptions form the basis of the current study and would not have been achievable through other means, such as questionnaires. Extended conversations help to establish both the commonalities and differences between the participant(s) and researcher as well as forming a space in which to clarify and negotiate the research agenda.

Bell's (2004) own experience of research with farmers in the USA offers a striking parallel to what became a vital component of researcher - farmer dialogues in my own study. Bell (p119) describes the development of his relationship to the study participants the following way: "I often felt myself the city boy during the research… I found it sometimes helped to make a joke of my outsider status, raising it and partially dissolving it at the same time". The farmers - by understanding that I stem from urban stock, could then describe for example, their farm management and decision-making methods with far greater detail than they normally would with somebody whose agricultural knowledge was at a similar level to their own. This cemented my position as student and positioned the farmers as my teachers, dispelling any notion of academic learning being above that of the farmers' own learning, effectively reversing roles as well as breaking down entrenched hierarchies and mutually held stereotypes. Developing a rapport with the study participants was thus vital to gaining a clearer insight to the range of factors influencing the farmers' outlook and actions resulting from their management. This enables a deeper level of questioning so as to avoid errors in interpretation rising from the researcher's limited understanding of each farmer's unique socio-cultural, environmental and economic context.

In-depth interviewing becomes an important issue particularly where an investigation of peoples' attitudes is involved, under the assumption that attitudes change and are specific to context (Gärling *et al.* 1991). Thus the advantage of carrying out a second, and in one case third interview is that a dynamic picture of the behavioural process of an individual can be revealed. This method also enabled farmers' ideas, experiences, issues and concerns further directions for research raised in the course of interviews to be reintroduced and re-examined through interviews with other farmers, in affect a form of triangulation.

Closed questions were used when answers of a briefer and more specific nature were required – such as when seeking definitions for a healthy soil, the specific indicators used and the types of monitoring practices used. As many of the interviews took the form of highly informal, extended conversations, a list of key questions was kept on hand as a prompt to ensure all themes were covered (Tolich & Davidson, 1999, pp120-121). Examples of questions used in the interviews are provided in Appendix six.

4 FARMER CHARACTERISATIONS AND INDICATORS OF SOIL QUALITY

4.1 Introduction

Soils in agricultural contexts provide moisture, oxygen and nutrients for plant growth as well as absorb the high concentrations of nutrients and pathogens generated by farm animals (Cornforth 1998:17). In New Zealand, pastoral agriculture holds the key position of major exporter (TPK 2002:22). With increasingly intensive landuse - particularly in the dairying sector (LIC and Dairy InSight 2004), it is imperative to direct research not only towards quantifying soil quality (SQ), but also how the soil resource is characterised, understood and assessed by the farmers who provide products for local, national and international markets. Aligning differing perspectives on what constitutes SQ can avoid scenarios where farmers despite having "…favourable attitudes to sustainable land management… don't apply measures as they do not realise they actually have a problem" (Vanclay 1992: 101). Sparling and Schipper (2004) for example show a trend toward increasing compaction (evidenced through decreasing macroporosity) over a 4-5 year period on Waikato farms and suggests that farmers may not necessarily be aware of the trend or implications in terms of loss of pasture production.

Recent feedback by farmers attending workshops in the wake of the New Zealand Growing for Good report on agricultural intensification (PCE 2004a), reveal an on-going need for farm-based, paddock-level indicators and monitoring frameworks. Furthermore, farmers expressed the need for a better understanding of "…what is happening, how it is happening, and why" in relation to the natural resources they depend on for their livelihoods (Nimmo 2005). For Māori in particular, there is a call for sharing their concerns over natural resource use with a broader audience. There is also a general need for reaching common understandings of monitoring, standards and management (Tipa and Tierney, 2003) in order to facilitate communication between farmers, extension workers and researchers (Niemeijer 1995). Arriving at common meanings is critical as experts for example are more likely to base descriptions on unambiguous scientific language which is not widely understood by farmers (Harris and Bezdicek 1994).

Approaching the question of SQ through the farmers themselves provides an insight into the most desired properties sought in order to reach productivity goals, and accordingly is the focus of this chapter. The objective is to capture farmers' descriptive language, as having farmers describe soil quality in their own terms will reflect their own needs as well as priorities. A second objective is to investigate the suites of SQ indicators farmers use and the way in which they use them. In recent years, farmer SQ indicators have been incorporated into easy to use SQ monitoring kits (Cramer 1994, Romig *et al.* 1996, Lobry de Bruyn and Abbey 2003, Shepherd and Park 2003). In contrast to highly technically oriented tools often developed in isolation from the end user (Pretty 1995, Tsouvalis *et al.* 2000), these SQ monitoring kits are typically designed in collaboration with farmers, for on-farm use by them. Many capitalise on farmers' abilities to visually assess resource condition through simple activities for example digging a hole (Shepherd and Park 2003). The primary aim of these kits is to support on-farm decision-making by providing the farmer with meaningful information able to be interpreted by the farmers themselves (Wander and Drinkwater, 2000).

The overall similarity between kits suggests a generalised suite of indicators used by farmers around the world. A third objective is therefore to investigate whether the concept of SQ, and the primary indicators used by arable and pastoral farmers are as universal as the literature suggests.

4.2 Methods

Semi-structured interviews[5] with 8 Māori pastoral farmers and family members who played a key role in farming operations began in February 2005 (summer) and continued until September 2005 (late winter). All interviews were conducted face-to-face either in the participants' home or while (literally) in the field, in the course of carrying out farm management activities. Interview length ranged from approximately 1 hour to most of the day dependent on the availability of participant and other factors such as the number of people present (e.g. other HWW and ARGOS staff) and location of the interview. As it was not feasible to re-interview all of the study participants, those selected for follow-up interviews were farmers currently linked to the HWW sustainable development programme. These interviews were carried out 4-6 weeks apart and covered similarly varied amounts of time.

Relevant Regional and District Council staff, agricultural consultants and soil scientists were also contacted and mined for their technical expertise as well as to discuss their experiences of communicating with farmers in different parts of New Zealand. These interviews either face to face or over the telephone, were loosely structured comprising a mixture of open and closed questions and were documented as themes in a field book. By mutual agreement between myself and the interviewees, no post-interview verification of the notes taken was seen as necessary in light of the highly informal nature of communications.

4.2.1 Interview documentation

Interviews were documented by tape recording, and notes taken during and after interviews. The desire of the participant combined with the nature of communication dictated the form of interview documentation. In some cases, interviews were tape-recorded or notes were made directly into a field book during interviews. In other cases, for example during preliminary meetings with participants or where interviews developed into wide-ranging conversations, tape recording was considered inappropriate. Here, the main themes emerging over the course of the day were summarised afterwards in a field book. Summaries were crosschecked with the other researchers that had been present to ensure all relevant information was included. Informal observational notes were also recorded in a field book after each of the farmer interviews, primarily in order to develop a greater understanding of the context of the individual – factors likely to impact, influence and direct the responses given by the individuals to the questions asked.

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[5] Interviews fall under the framework of the ARGOS ethics, which in turn have been accepted by the University of Otago Human Ethics Committee (approval number 05/035).

In all cases either transcripts or typed summaries of themed notes taken were either posted or emailed back to participants for verification. In one case, the recording instead of the transcript was returned. Participants were then phoned or emailed to discuss any modifications they felt necessary to the transcripts/ summaries and corrections to the original texts were made either over the phone or sent by email. Copies of the recordings and transcripts of HWW farmers (F1, F2 and F3) were lodged with HWW as resources to support both current and future research initiative

4.2.2 Grounded Theory

Grounded Theory (Glaser & Strauss, 1967) was used as the analytical method for this study. A basic list of preliminary codes was used to identify content that referred to the initial themes (Miles and Huberman 1994). A list of the codes used can be found in Appendix five. Coding was done by hand as the nature of documentation varied (full transcripts to thematic summaries). The process of reading and rereading transcripts/ summaries of interviews enabled a greater degree of familiarity and intimacy with the content, thus greatly facilitating the development of subsequent directions of inquiry. Emerging sub-themes were then further investigated either through further interviews and/or follow-up phone calls. The list of interview questions thus developed progressively, influenced by what emerged from the other interviews and through on-going analyses of interview content against available literature.

4.3 Results

Two broad directions of inquiry emerged from the discussions with farmers. The first way of describing SQ centres on soil properties: the physical, biological and chemical make-up of the soil. These can be regarded as inherent properties, derived from basic soil forming factors such as climate, parent material, time and topography (Karlen *et al.* 2003). Extending from these key soil properties are the way in which the pasture species (e.g. rye and clover), forage crops and animals perform. For all of the farmers interviewed in the current study, a good quality soil is a productive soil, in other words has the desired sets of attributes which enable it to be productive. By contrast, the next three indicator categories (cover crop, stock condition/overall production and stock movement) though dependent on a healthy resource base are also influenced by variables such as nutrient inputs and climate. The second way therefore of describing SQ is linked to management, as land use as the major driver of SQ (Hill *et al.* 2003). SQ in this sense is dynamic, a property which can be improved, maintained or degraded (Karlen *et al.* 2003). The degree to which a soil needs to be modified in order to reach production goals also influences whether the soil is described as good quality or not. A "good" soil for example could be modified to increase levels of productivity. Although SQ effectively exists on a continuum, for many farmers the notion of SQ is simply dichotomous: the soil is either good quality or not; well suited to its current use or not (Romig *et al.* 1996). In this way, almost the opposite characteristics are used to describe lower quality soils:

> *F5 Volcanic is a good soil… a mix of rock …and the topsoil quite deep… the lighter [textured] soils dry out quicker, [they're] more porous…. doesn't seem to hold water; doesn't turn to mud with a bit of moisture; doesn't have the same number of worms…*

The farmers in this study are spread over a range of locations in the southern part of the South Island of New Zealand. Farms cover a range of soil types including brown, recent, melanic, gley and pallic soils (see Hewitt 1993). The key indicators resulting from the farmer interviews are grouped together on the following table as individual components within clusters though are not ranked hierarchically in line with the semi-structured nature of the interviews.

Table 1. Key soil quality indicators from farmer knowledge (current study)

INDICATOR CATEGORIES	INDICATORS of "Good quality soil"
Physical characteristics	- Soil colour - Drainage and infiltration - Soil smell, feel, texture and weight - Constituents of topsoil and subsoil - Level of / resistance to compaction and pugging - Level of / resistance to erosion - Slope and aspect
Biological characteristics	- Presence of desirable invertebrates - Rate of organic decomposition
Chemical characteristics	- Soil fertility - pH and levels of other primary nutrients
Cover crop	- Pasture recovery times; pasture growth rates - Pasture composition - Pasture colour; sward thickness - Rooting depth - Species and quantity of weeds present
Stock	- Stock movement - Stock condition and overall production levels

Many of the indicators discussed by the study participants relied on sensory experience: touch, sight and smell combined with daily and seasonal farm activities such as digging, fencing direct drilling, harrowing and ploughing. The way in which farmers SQ assessments are made typically centres on the grouping together of a number of different indicators, as many of the interview excerpts on the following pages clearly demonstrate. Single visually obvious indicators while valuable in themselves for their ability to describe a number of different conditions to the farmer, are still ultimately supported and confirmed through a range of other indicators. For example, a desired species of pasture grass if lush and deep green, may indicate adequate nutrient levels, low or no levels of compaction as well as effective drainage.

4.3.1 Soil physical characteristics

In most studies, farmers' descriptions of SQ relate primarily to the surface horizons or the plough zone i.e. the upper 15-30 cm of soil. This is where the main management activity takes place and the topsoil or arable layer forms the zone of greatest direct impact on factors such as grass growth (Niemeijer 1995, Romig *et al.* 1995, Desbiez *et al.* 2004).

Topsoil was commonly referred to as “dirt”, with overall quality determined by the ratios of its constituents. Good soils were described in the following ways:

> *F2 …not too much sand, feels ‘dirty’ …more like ‘potting mix’*

> *F8 …sort of a clayey, sandy loam type of soil*

The range of soil constituents described by farmers i.e. clay, loam, silt and sand, corresponds to widely used descriptive types. However, it is worth noting that “dirt” to a farmer though synonymous with (top)soil, may not necessarily include a judgement on its quality (*cf.* Lobrey de Bruyn and Abbey 2003).

The textural qualities of the soil were often expressed as the degree of “crumbliness”, “looseness” or conversely as “tightness”. The resistance encountered against the spade while digging, the “soil feel” was an important rapid assessment method:

> *F6 ….see, that’s all nice and broken up (crumbles soil in hand) whereas when you’re cutting into that [soil] it’s like cutting into a lump of clay…*

Mechanical penetration was not highlighted (*cf.* Bloomer 2002) as the farmers in this study only crop for forage, a standard practice in NZ (White *et al.* 2002). Although the bio-physical indicators most often referred to were predominantly located in the upper soil horizons, subsoil features were also discussed in light of their contribution to moisture retention and release:

> *F6 …the best times when its wet have been the river flat here… bit of a stony, gravely base or river shingle I suppose you’d call it…still got plenty of stone in it, water seems to run off it fairly well*

Vulnerabilities or limiting factors inherent within the different soil types were well known by the farmers in their respective regions:

> *F7 …drainage is a big thing, especially in this area because it’s dead flat, it’s a shocker, and this is gravel-based pan and there’s no hills, so drainage is quite an issue here…*

In this sense, SQ becomes a problem-identifying concept (Lobrey de Bruyn and Abbey 2003), where the farmer uses knowledge relating to the soil type to focus and direct their observations and adjust their management accordingly.

Ditzler and Tugel (2002) note that farmers generally consider drainage and infiltration as a combined indicator for pasture/crop management, while researchers often assess these properties separately. This suggests that farmers do not need to separate soil water relations in the same way, instead relying on their awareness of how well the soil responds to for example, rain events. Only one farmer in this study separated - at least verbally, drainage and retention. By using the term “ideal conditions”, the farmer demonstrates that a particular image of soil health exists:

> *F4 …tend to gauge [soil health]… in terms of ideal conditions, water drainage, water retention…*

Soil water related indicators rely on the on the farmers’ observation skills and ability to informally measure the degree of change over time, in other words rely on their memory. Romig *et al.* (1995) highlight the importance temporal observations, as water collecting or running off the surface though indicating the ability of the soil to absorb water, does not immediately provide clues as to the subsoil’s ability to drain or retain water. Thus a general description of the quality of the soil centres on its resilience to climatic events such as drought or excessive rain. The resistance of soil to erosion was raised by two farmers with paddocks on hilly land. Erosion was not mentioned by other farmers as the paddocks on the other farms were predominantly flat.

Soil colour is a widely used indicator and combined with basic soil physical properties used forms the basis of extensive “folk” or “traditional” soil taxonomies (Birmingham 2003, Williams and Ortiz-Salorio 1981, Bellon and Taylor 1993, Haburarema and Steiner 1997, Niemeijer and Mazzucato 2003, Oudwater and Martin 2003). Generally speaking in the current study, the colour of the soil: “the darker the better” (F2) formed a useful, though very general indicator of SQ as the darker the soil, the greater the amount of organic matter it contains (Cornforth 1998: 9). In one instance, the origin of what the farmer considered good quality soil was described:

> *F1 …if you can get a Kamahi[6] forest to die on it, comes up real good, don’t know whether it’s the rotting process or what’s in the trees, it’ll go black, like jet black, real good, goes real good.*

Soil colour, as an obvious feature also lends itself to making comparisons to other soil types; a form of rapid assessment:

> *F6 …oh, seems to be good soil, it’s not black… like market gardeners like it nice and black, [our soil’s] more like ah dark brown…*

Smell has put forward as a general indicator of soil health with traditional or folk wisdom suggesting that poor quality soil can be detected by a “sour chemical” or “off” smell, where good quality soils have a “pleasant, earthy” smell (Kennedy and Papendick 1995, Romig *et al.* 1995). Within Māoridom, the district known as *Te Whenua i hongia e Turi* – the land that Turi smelled, refers to the siting of historic gardens selected through smelling the soil (Roskruge 1999b). Desbiez *et al.* (2004) also describes Nepali farmers as using smell to indicate the

[6] *Weinmannia racemosa*

fertility of the soil and smell is suggested by Habarurema and Steiner (1997) as one of a suite of characteristics on which to base a land evaluation system for farmers. Although few of the farmers in this study specifically mentioned smell as a component of soil health, one farmer described the function of smell in the following way:

> *F5 …in situations where it's really waterlogged… gets a sort of tang about… water's been lying, sitting…on top of [the soil] for a while, actually things dying… that smell – decomposing; but that, you can see that as well obviously.…*

4.3.2 Soil biological characteristics

Most farmers mentioned worms and related their presence to levels of good soil fertility as well as to soil physical quality. As with other studies (see Nimmo 2005), farmer understandings and knowledge of soil biological processes were generally limited. Worms, being one of the most conspicuous soil fauna, were typically observed in the course of daily activities rather than being specifically sought out by study participants:

> *F6 yeah, …we… dug the [fence posts] along the drain over there… we just noticed a few worms and stuff…*

By adding "…actually, probably should have taken the time to have a really good look…" (F6), the farmer acknowledges the likely importance of observing worm numbers in the soil. Only one farmer specifically mentioned a wider range of soil fauna, which in this case may reflect formal technical training:

> *F4 I just look for a diversity... just see what's there, if there's not a lot there, [the soil's] not really healthy… it's really subjective... I just really look for what life is in the topsoil and see that as a general health indicator.*

Pasture pests such as grass grubs (*Costelytra zelandica*) though mentioned by two farmers, were not regarded as specific indicators of soil health *per se*. Instead these pests form part of an aggregate of indicators.

4.3.3 Soil chemical characteristics

Primary nutrient levels were measured predominantly through soil tests or relied on the farmers' general knowledge of the local soil characteristics. Soil pH was most frequently mentioned both directly and indirectly in terms of the necessity to apply lime, and thus forms an important and visually obvious indicator through its link to pasture/weed species composition. The most frequent mention of pH was in Westland, where "everyone knows that they need lime…" (F2). Strongly leached, acidic soils are a prominent feature of this region (Molloy 1998:166), though in the other regions explored in this study, pH was not a major limiting factor[7]. The term generally used to describe the nature of acidic soil was “sour”, hence needing “sweetening up” with lime in order to improve productivity. Soil fertility forms a component of soil health and although measuring soil chemistry requires laboratory analysis (Cornforth 1998:18), farmers used a number of visual clues such as plant colour as general indicators of nutrient levels. The effects of magnesium and nitrogen were mentioned in relation to the grass - though only by the farmers in the study who used laboratory soil tests:

> *F6 …a lot of it you can tell just by looking at the grass… if it's red or if it's yellow… if it's red, it's a lack of magnesium…*

The species of both pasture and weeds present also provide an indication of soil fertility levels. Changes in pasture species composition such as the decrease in ryegrass and white clover and an increase in annual species such as hairgrass (*Aira ssp.*), sweet vernal (*Anthoxamthum odoratum*) and goosegrass (*Galium aparine*) indicate that the nutrient status of the soil has declined (Cornforth 1998:217).

> *F1 We've dumped a fair bit of lime on these paddocks here and they've certainly showed the worth for it [...] the rushes go… the cutty grass[8] seems to go once you sweeten the soil up, seems to knock it back.*

Similarly, the presence and distribution of species more tolerant of waterlogged conditions such as rushes (*Juncus ssp*.) and buttercup (*Ranunculus ssp*.) also provide the farmer with strong visual clues as to drainage needs within the paddock.

4.3.4 Cover crop

Grass growth emerges as a primary indicator of soil health in a number of New Zealand studies (see Wilkinson 1996, Parminter *et al.* 1997, Bennett *et al.* 1999, Bloomer 2001), which is not surprising given New Zealand's reliance on pastures for stock grazing (Matthews *et al.* 2002b). The focus on grass growth as a primary indicator linked to soil condition, is explained by one farmer in the following way:

> *F7 …for us it's just grass growth – that's the game we're in… grass growth and production…*

Pasture condition, in particular the colour, thickness of the sward and growth rates were emphasized by all participants. For one farmer, determining SQ through visual appraisal of the cover crop was “…about the only way we can tell really…” (F6) in other words providing proof that the soil was in good health. Pasture recovery rates to both grazing pressure and

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[7] Alkaline or sodic soils were not a feature of any of the soil types in this study and are rare in New Zealand (Molloy 1998:159), therefore the attributes of these soil types did not emerge as indicators.

[8] *Carex ssp.*

adverse weather conditions (such as drought) were also highlighted. One farmer, with a keen knowledge of the distinctly varied soil types on the property, described the correspondingly different rates of grass growth as related to the topography and geology of the farm. Though not explicitly stated by the farmer, these observations reflect a strong understanding of the moisture retention qualities of the different soil types. The effects of water-logging and soil compaction both impact on the rooting depth of the crop grown:

> *F6 … [this brassica is] supposed to be twice the size… that's what compaction does, wet ground; the fertility's still the same… when we planted this [brassica] we did the same with this [points to wet part of paddock] as the whole paddock…*
>
> *F7 …where it falls apart just underneath the soil [about 15 cm] and you'll see it compacted there […] and just under that you'll see… the roots are not going down…*

4.3.5 Stock movement, stock condition and overall production

A decade ago, it was suggested that the lack of emphasis on soils by NZ farmers resulted from their lack of knowledge of what to look for. It was felt that farmers were more aware of changes in stock condition, this being more visible than changes in soil condition (Wedderburn 1995). The emphasis on the end product is a prevalent theme in the interviews with the strong emphasis on production explained in the following way:

> *F7 …we look at the cow… because we understand cows more than soil.*

The farm as a feedback cycle is aptly demonstrated by the following interview excerpts. While a healthy resource base provides the foundation for healthy products, inversely the product itself i.e. the stock, can be used to provide clues as to the health of the resource base:

> *F4 [I] look at [the soil] in terms of what weeds are around […] where the stock 'camp' can indicate what they're eating what they're not eating… what places they're favouring for grazing, what they're not grazing…*
>
> *F3 …to make the land productive, you've gotta make it healthy… nice looking sheep and nice looking cows!… well that's the product that comes from that land, what you can produce from land…*

Healthy stock may well be the ultimate indicator of overall system health (Wilkinson 1996), as in many cases, stock are the major end-product of the farm.

4.3.6 Farmer control of soil quality

Management can have a greater effect on the ability of the soil to function more so than inherent soil characteristics (Sojka and Upchurch 1999). In New Zealand, adverse impacts on SQ are often linked to stock treading, or tillage and traffic associated with cropping, with structural breakdown possibly emerging as the most notable indicator (Bloomer 2002). Beare *et al.* (1999) showed that when the structural condition of soil declines below approximately 5 on a 10-point scale, profitability declines rapidly. Despite the limitations of inherent soil properties, SQ is seen to a large degree as dynamic, something over which the farmer can exert control and modify according to land use practice (Romig *et al.* 1995). Asking farmers which types of management have the greatest effect on SQ therefore reveals the way in which farmers understand and manipulate their resource in order to meet individual production goals. The following excerpts are examples raised by farmers of key management activities which may impact on SQ.

4.3.6.1 Stocking rates

F6 …probably not so much the actual putting the crop in that buggers the soil, its when you put 400 cows on it to eat it you see… they're up to their bellies in mud on some parts…

4.3.6.2 Ploughing

F6 …[too much ploughing] makes it more powdery and powdery and powdery, ….it gets almost like horticultural [soil]… it was raining and raining [here] and water was just sitting on the surface…. you break off the surface and there's just powder underneath…

4.3.6.3 Cropping

F7 …any paddocks we deem there's something wrong with it we'll just rip it up, plant crop in it… brassicas, we'll do 2 years then it'll go back into young grass… It's been decompacted I suppose, and it's been all turned over, flipped over, we've fertilised it, then when it comes back into young grass, it flies, it's just brilliant… that's what you aim for, you take your poorest soils out, whip 'em out, put 'em into crop…

4.3.6.4 Weed control

F3 …what happens when you burn the gorse you burn the dirt too, the black dirt burns, that's why the land is so sour here… when you burn black dirt you end up with clay; topsoil goes away… goes up in smoke.

The farmers in this study emphasized the importance of good soil management. Although economics formed a strong driver dictating farm management type as well as the extent of the management. While many farmers described how their productivity could be improved, the financial means to do so for some farmers precluded carrying out the necessary work.

F6 …if you bugger [the soil] up, you're back to square one ….

F7 We try not to wreck it, don't pug the paddocks, doesn't matter what you do…stand the cows on the road, race whatever. You can't afford to because … once you pug it…it's worthless… you damage the paddocks and you've lost it.

While the above statement discusses correct management in terms of its linkage to farm profitability, on another level, by “losing it”, the farmer also refers to “losing” the understanding that the fundamental importance of the soil relates to its base function: to support and enhance farm productivity.

4.4 Discussion

The farmers in this study ascribed a wide range of attributes to what they considered a healthy soil. Being livestock farmers they manage a whole production system, which combines a range of natural resources namely animals, vegetation, soils and water. The attributes thus chosen by the farmers, while including components within the soil system itself, also encompassed some of the key aspects of agricultural production such as plant growth and animal health.

Harris and Bezdicek (1994) in consultation with Wisconsin farmers developed an Interpretative Framework that views soil health as nested within "target systems" (Figure 3). These systems are identified as the soil itself; plant (crop); animal/ human; water and air. Within each of these target systems are both descriptive measures (based on sensory experience) and analytical measures (based on chemical, physical and biological factors).

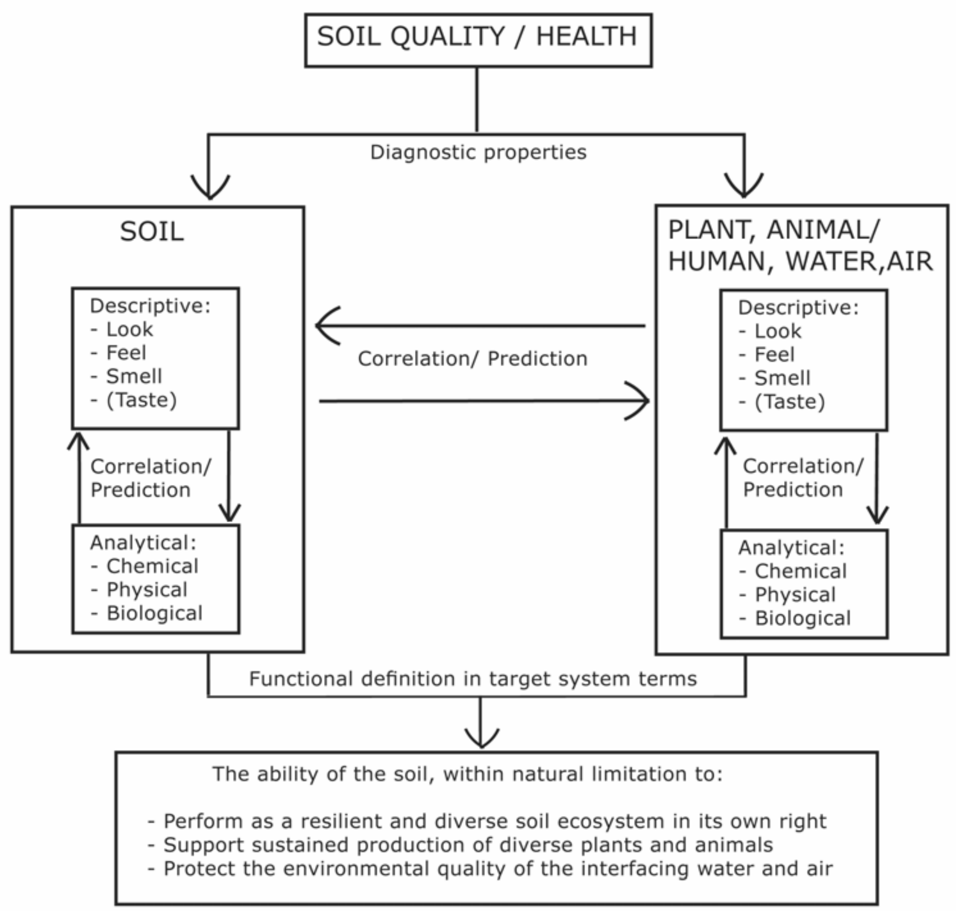

Fig. 3 Soil quality/ health interpretative framework after Harris and Bezdicek (1994)

Note that the relationship between the descriptive and analytical measures are hypothesised as mutually supporting: descriptive measures correlate with specific chemical physical and/or biological measures, allowing prediction from one type of measure to the other (Harris and Bezdicek 1994).

In contrast to the Soil Quality/Health Interpretative Framework which views soil health as nested within the 5 target systems, the categories in Table 1 (physical, biological and chemical characteristics; cover crop and stock), follow the separating and linking of indicators in much the same way a farmer automatically does. There is a certain lack of logic in placing for example, worms in the "animal" category along with stock when worms are one of the key features described *alongside* and linked directly to soil physical properties and nutrient status. Despite Harris and Bezdicek's assertion that employing this framework is necessary in order to understand how diverse interest groups recognise and measure SQ, this study found that no farmers chose to link soil health to "human" health or "air" quality. Bennett *et al.* (1999), using the framework show similar results with Manawatu farmers also not recognising the categories of air and human. For the purposes of tool development, although undoubtedly some connection exists (albeit in a highly diffuse way), incorporating categories of human health and air quality may create undue levels of complexity[9]. Unless the connections are directly relevant to farmers – and make sense – then these will not form part of the farmers' suite of indicators for assessing SQ (Wiley *et al.* 1993, cited in King *et al.* 2000).

In order to examine the scope of indicators used by farmers, this study extended across four distinct regions, Canterbury, Otago, Southland and Westland and covered a corresponding range of soil types. Other studies have focussed on geographical regions with similar soil types to isolate for variables (e.g. Romig *et al.* 1995, Wilkinson 1996, Bennett *et al.* 1999, Grossman 2003, Lobry de Bruyn and Abbey 2003, Desbiez *et al.* 2004). Additional variation in this study centred on the diversity of farm operating levels, which covered a spectrum from extremely low or almost no input systems to high input systems, reflected in the condition and productivity of the pastures. In the low input systems, for example, some of the pastures were in the process of development, in other words activities such as subsoiling, drainage digging, forest clearing and weed removal (e.g. blackberry, rushes, gorse) spraying, discing and digging-under were taking place. In contrast to the higher input systems, pastures were highly developed in line with production goals (see Appendix six for farmer demographic).

Yet despite the localised and complex nature of soil the key indicators to emerge in the current study show strong similarities to international studies (see examples in Table 2.).

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[9] Interestingly, Wander *et al.* (2002) found farmers in Wisconsin included such broad scale categories such as "environment" and "economic" to describe soil quality - though does not list the specific questions asked of farmers.

Local or indigenous soil taxonomies and land use capability assessments are primarily based on conceptual or utilitarian values (Niemeijer and Mazzucato 2003). As such, they highlight key diagnostic features which guide, for example the choice of crop and its management or type of animal production system. The strong emphasis on soil physical properties highlights the importance of managing the soil to provide optimum conditions for plant growth. This echoes what Cornforth (1998: 22) suggests: that farmers require more skill and experience to manage the soil physical properties than is needed to manage the nutrient supply.

Table 2. International farmer indicators of soil type used in indigenous soil taxonomies and land use capability assessments

STUDIES	Location	**FARMER INDICATORS**
Birmingham (2003)	Cote D'Ivoire	Colour, texture, water holding capacity, workability
Cools *et al.* (2003)	Syria	Colour, texture (e.g. gravely, stony), slope (location in the landscape)
Desbiez *et al.* (2004)	Nepal	Colour, crop yield, soil hardness, weeds
Ericksen and Ardon (2003)	Honduras	Texture, landform type, organic matter content, topsoil depth, colour, infiltration, drainage, water holding capacity
Haburarema and Steiner (1997)	Rwanda	Fertility, depth, texture (e.g. stoniness) colour, consistency (e.g. stickiness), drainage, fallow vegetation, structure, subsoil
Niemeijer and Mazzucato (2003)	Burkina Faso	Colour, texture, constituents (soil organic matter, amount of gravel, sand, loam) water holding capacity, drainage ability, topography (location within the landscape)
Oudwater and Martin (2003)	Tanzania and Uganda	Colour, texture (e.g. sandy, sticky), water holding behaviour, susceptibility to erosion, suitability for crops and the associated vegetation, management problems
Sikana (1994)	Zambia	Colour, texture, consistency, organic matter content
Williams and Ortiz –Solorio (1981)	Mexico and Guatemala	Colour, texture, moisture, workability, vegetative cover

Combining the 4 recent soil quality related studies which have been carried out in New Zealand (Wilkinson 1996, Parminter *et al.* 1997, Bloomer 2001, Bennett *et al.* 1999) produces an almost identical suite of farmer selected SQ indicators which can likewise be grouped into the same general categories (i.e. soil physical, chemical and biological characteristics; cover crop and stock condition / movement) as was done in the current study[10]. Lobrey de Bruyn and Abbey (2003) also arrive at a similar suite for their Australian study. This underscores the potential functionality of a basic suite comprising approximately 13 indicators. Additionally, these core indicators are well correlated with beneficial soil functions, and function as excellent teaching tools because they reveal ecosystem processes (Doran and Zeiss 2000). While there are many other more subtle observations made by farmers - Romig *et al.* (1995), for example records 97 different SQ indicators recognised by farmers (n=28), a total of 13 indicators is perceived by farmers to be a manageable number for developing SQ assessment tools. The addition of too many categories for measurement results in an unwieldy and unnecessarily complex method of soil assessment (Parminter *et al.* 1997).

4.4.1 SQ monitoring kits for farmers

The focus in recent years on developing kits for farmers to use by themselves on their own farms to measure SQ recognizes that farmers as landusers possess skills and understandings that could potentially be used in a more systematic manner. As the interviews in the current study demonstrate, farmers' observations and experiences of the soils on their land is largely part of a daily and seasonal process of management and as such is not documented on paper.

A characteristic feature in the development of many farmer SQ monitoring/ assesment kits is the extensive use of interview techniques to collect and categorise farmer knowledge, experience, and importantly, descriptive language. Kits are thus simultaneously developed from and oriented toward the end users in contrast to tools of a more technical nature (see Tsouvalis *et al.* 2003). The need to align understandings of soil condition is highlighted by Vanclay (1992: 101) who describes the prevalence of "worst case scenario" images typically put forward to illustrate issues such as soil erosion as reinforcing larger scale as opposed to less observable processes. Farmers may therefore not recognize the extent of the degradation that has already taken place.

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[10] Key differences in indicators between the current study and other New Zealand studies include "parent material" (Parminter *et al.* 1997) which may reflect the angle of questioning; "mechanical penetration" which indicates a focus on cropping systems (Bloomer 2001), as well as droughtiness / soil moisture retention which reflects the climate and soil type of the region studied (Parminter *et al.* 1997).

The Wisconsin Soil Health Scorecard (Romig *et al.* 1996) enables farmers to evaluate the interconnected soil, plant, animal and water properties on their farms. A function of the Scorecard is to promote an increased awareness of the soil resource through encouraging landowners / farm operators to ‘‘look below ground’’ when evaluating their soil management practices (Karlen *et al.* 2001).

Table 3. Example of statements from the Wisconsin Soil Health Scorecard

DESCRIPTIVE PROPERTIES	SCORE
Earthworms O – Little sign of worm activity 2 – Few worm holes or castings 4 – Worm holes and castings numerous	
Soil Structure O – Soil is cloddy with big chunks, or dusty and powdery 2 – Soil is lumpy or will not hold together 4 – Soil is crumbly, granular	
Color (moist) O – Soil color is tan, light yellow, orange or light gray 2 – Soil color is brown, gray, or reddish 4 – Soil color is black, dark brown or dark gray	
Infiltration O – Water does not soak in, sits on top or runs off 2 – Water soaks in slowly, some runoff or some puddling after a heavy rain 4 – Water soaks right in, soil is spongy, no ponding	

The Scorecard uses easily interpreted statements based on indicators (found in the plough layer) linked to the capacity of the soil to carry out functions such as infiltration, decomposition and nutrient cycling. Fundamental soil attributes such as soil colour and structure, root morphology and animal health are also included (Romig *et al.* 1995) as these are typically employed by farmers as a matter of course.

As the farmer-based SQ assessment tools are suggested as a means toward maintaining or even improving on farm soil quality, it is worthwhile noting a general gap in the literature on monitoring farmers' usage of SQ tools as well as evaluating whether the abovementioned outcomes are achieved. While this largely reflects the newness of these innovations, it also highlights the desperate need for future research in this area. Evaluations to date are largely focused on the comparative testing of field to laboratory measures (e.g. Evanylo and McGuinn 2000, Shepherd *et al.* 2004, Liebig *et al.* 1996, Cramer 1994) or comparing the accuracy of tool use between experts and non-experts (e.g. Shepherd *et al.* 2001).

4.4.2 Issues with farmer SQ indicators

Many of these kits are based on the premise that soil health can be determined through the health of the cover crop. This has generated a heated debate in which the validity of farmer SQ indicators is questioned. An obvious example is smell, where there is no supporting research to show its utility as a quantifiable indicator of resource condition let alone management decision aid (Sojka and Upchurch 1999). This highlights the division between what is considered to have scientific value and what has value and meaning to the farmer. A further issue lies with in the multifunctional nature of each of the indicators. While this means that a single indicator that integrates a number of functions lessens the time spent assessing resource condition - time being a major consideration for farmers (Bloomer 2001), conversely it also means that a single indicator cannot meet the multiple criteria of SQ (under the wide ranging definition outlined by Allen *et al.* 1995). Sojka *et al.* (2003) argue that high quality soil for environmental protection does not guarantee high quality for crop production or biodiversity, bioactivity and sustainability, "…high quality for one function often predisposes poor or at least impaired soil quality for other simultaneous functions".

Using indirect or proxy measures (*sensu* Gray 2005) such as plant growth are problematic as many factors other than soil physical properties and fertility levels influence plant growth (Cornforth 1998: 216). Furthermore, the specific needs of individual crops may exert a greater influence than the range of soil properties encountered within each soil taxa (Sojka and Upchurch 1999). Yet crop condition is repeatedly mentioned by farmers as being a key indicator for determining the condition of the soil (Wilkinson 1996, Bloomer 2001, Williams and Ortiz –Solorio 1981, Lobrey de Bruyn and Abbey 2003, Romig *et al.* 1995, Parminter *et al.* 1997, Bennett *et al.* 1999, Desbiez *et al.* 2004) and as such, is included as an indicator in farmer-based SQ assessment kits (see Shepherd and Park 2003, Romig *et al.* 1996). The repeated use of "texture" within the taxonomies listed in Table 2 corresponds with contemporary soil science which acknowledges the influence of texture on properties such as water retention, permeability and drainage; structure and consistency (Talawar and Rhoades 1998).

4.4.3 Holism

The deficiencies of the indicators however may be offset when considering the way in which they are used. A single indicator forms part of an aggregate of others and thus separating each out, while providing tangible points of reference, hides the subtlety and complex nature of farmers' observation. Fitzgerald (1993) provides an example of farmers "reading" corn and in doing so translating the physical characteristics of the ear into meaningful indicators of quality, yield and insect resistance. This is analogous to farmers "reading" their landscape, e.g. rapidly appraising stock, cover crop condition, water pooling and thus formulating overall measures of system health.

Farmers are described as having a holistic view when compared with the reductionist approach commonly taken by soil scientists / technical specialists (Farrington and Martin 1988, Pretty 1995, Siderius and de Bakker 2003, Cools *et al.* 2003). The philosophy of holism is pervasive in Māori culture and embodied in the phrase *Ki Uta Ki Tai* – from the mountains to the sea. In this way, Māori gain understanding more from an appreciation of the whole and the relationships between phenomena and structures more so than from the ability to identify individual components (Durie 1996). Certainly for most of the farmers in the current study, these connections were openly expressed - without a direct question being asked in the interviews. Holism is integral to understanding a farm because the farm is the product of the interaction of parts, the farm itself cannot be adequately described or understood through simply adding together the objects or separate parts (Kelly and Bywater 2005). As Cools *et al.* (2003) dryly comment, "… land resource experts need a multidisciplinary team to come to the same conclusion…" as farmers, who in many respects follow holistic principals as a matter of course. Holism thus signifies more than just a sum of parts – holism includes the interaction between parts (Kelly and Bywater 2005). The indicators farmers use and the way in which they use them must be understood in terms of the web of causes and effects that link them. A basic example of this process follows:

> *F7 I look for grass grub, again, that's the visual look of the paddock, if there's something wrong with it… brown patches on it, so you might go and you might dig it up…*

This process demonstrates how strongly the farmer relies on visual knowledge of the effects of certain indicators. With a range of indicators, the farmer can seek confirmation from other indicators before a management activity takes place as farmers are unlikely to base management on a single indicator. This aptly demonstrates that indicators are not perceived to be independent entities by farmers, though at times causal mechanisms may not be fully understood (Murdoch and Clark 1994).

Romig *et al.* (1995) found that farmers were still able to be sensitive to the condition of the soil resource through the range of largely informal measures. In the USA, Liebig and Doran (1999) compared farmers' knowledge of soil quality to indicators determined by the established assessment protocol. Farmers' perceptions were correct or nearly-correct over 75% of the time for the majority of indicators evaluated in the study. On a more global level, aggregates of qualitative indicators and informal resource monitoring methods form the basis of agricultural systems and have developed over centuries, even millennia (see Sandor and Eash 1991, Sikana 1994, Sillitoe 1998, Pawluk *et al.* 1992, Desbiez *et al.* 2004). This strongly suggests that using subjective measures may be enough to enable farmers to act before critical conditions are reached (Parminter *et al.* 1997).

4.5 Conclusion

The farmers in this study described and assessed SQ through a range of indicators based on a combination of inherent soil qualities (e.g. structure), processes which occur within the soils (e.g. decomposition) as well as the overall quality of the products (i.e. stock and crops) derived from the soil resource. This range of indicators and the integrated way in which they are used reflects the nature of the farm as a complex system. This study shows that despite semantics[11], farmers (with a little prompting) articulate very clearly what they consider to be a healthy soil and what is not, despite many not actively using the terms "soil health" or "soil quality" in day-to-day conversation. Although the farmers were quick to point out their lack of knowledge of soil types as classified scientifically (and in some cases technical knowledge), this did not prevent them from detailing the qualities of the soils that mattered most to their activities. The range of indicators used are broad and therefore asking a farmer the seemingly simple question "How do you describe a healthy soil?" opens up a universal and wide-ranging discussion covering inherent soil properties, outputs as well as the effects of differing forms of management on the soil. This discussion also encompasses worldviews in which individual and collective culture play important guiding roles in terms of how the soil resource is understood and consequently managed. As this study and comparative international studies show, there is substantial overlap between farmers' and researchers' perceptions of soil quality. While there are strong disagreements in the way that soil quality should be assessed, the choice of many of the key SQ indicators farmers which link to those selected by scientists show that there can be useful dialogue.

[11] Sojka and Upchurch (1999) argue that the meaning of "quality" has multiple meanings according to context, i.e. "Soil quality means different things to different audiences, in different places and even on different days" (Sojka *et al.* 2003)

5 UNDERSTANDING THEIR SOIL: FARMER LEARNING, FARMER KNOWLEDGE

5.1 Introduction

In recent years, an increasing amount of literature has focused on investigating the ways in which farmers learn (Sillitoe 1998, Grossman 2003, Ryder 2003, Scoones and Thompson 1994, Chambers *et al.* 1989, Okali *et al.* 1994). The initial emphasis on developing countries has now expanded to include OECD countries (Lyon 1996, Wilkinson 1996, Millar and Curtis 1999, Lobrey de Bruyn and Abbey 2003, Romig *et al.* 1996). The rationale underpinning research into farmer methods of learning and knowledge is that valuable insights can be gathered to aid the development of effective and practical approaches to sustainable agricultural systems.

Knowledge construction is the process of defining reality. As such, it includes the way in which social, cultural and physical environments are both recognised and interpreted (Raedeke and Rikoon 1997). Knowledge is contextual as the locations where each person, for example farmer or scientist, produces knowledge differs. These “knowledges” differ both in content and orientation (Eshuis and Stuiver 2005). In order to describe specific forms of knowledge developed over time by people in a given community, a proliferation of terms such as “local”, “folk”, “traditional” or “indigenous technical” are used (Sillitoe 1998, Williams and Ortiz-Salorio 1981, Pawluk *et al.* 1992, Cools *et al.* 2003). In New Zealand, the term mātauranga is applied to the Māori concept of knowledge (Mead 1996, Parsons 2000, Moller 2001, Harmsworth *et al.* 2004).

This chapter investigates farmer knowledge and farmer learning from two angles. The first is how Māori farmers learn about their soils and the management of them and the second, which sources of information are used and most trusted. Combining these angles illuminates some of the underlying dynamics within the agro-ecosystem. Broadly speaking, gaining an understanding how farmers learn and which information they rely on can provide an insight into ways of creating stronger links between the actors in the agro-ecosystem. In the process, mutually held stereotypes can be broken down as culturally responsive methodologies of research and extension are developed. In many situations, there is still a perceived divide between rural and urban, the latter being so distanced physically and culturally from farmers (Tsouvalis *et al.* 2000). Exploring farmer knowledge highlights actual and potential gaps both in the type of information required as well as in how knowledge moves between actors.

5.2 Methods

Semi-structured interviews[12] with 8 Māori pastoral farmers and family members who played a key role in farming operations began in February 2005 (summer) and continued until September 2005 (late winter). All interviews were conducted face-to-face either in the participants' home or while (literally) in the field, in the course of carrying out farm management activities. Interview length ranged from approximately 1 hour to most of the day dependent on the availability of participant and other factors such as the number of people present (e.g. other HWW and ARGOS staff) and location of the interview. As it was not feasible to re-interview all of the study participants, those selected for follow-up interviews were farmers currently linked to the HWW sustainable development programme. These interviews were carried out 4-6 weeks apart and covered similarly varied amounts of time.

Relevant Regional and District Council staff, agricultural consultants and soil scientists were also contacted and mined for their technical expertise as well as to discuss their experiences of communicating with farmers in different parts of New Zealand. These interviews either face to face or over the telephone, were loosely structured comprising a mixture of open and closed questions and were documented as themes in a field book. By mutual agreement between myself and the interviewees, no post-interview verification of the notes taken was seen as necessary in light of the highly informal nature of communications.

5.2.1 Interview documentation

Interviews were documented by tape recording, and notes taken during and after interviews. The desire of the participant combined with the nature of communication dictated the form of interview documentation. In some cases, interviews were tape-recorded or notes were made directly into a field book during interviews. In other cases, for example during preliminary meetings with participants or where interviews developed into wide-ranging conversations, tape recording was considered inappropriate. Here, the main themes emerging over the course of the day were summarised afterwards in a field book. Summaries were crosschecked with the other researchers that had been present to ensure all relevant information was included. Informal observational notes were also recorded in a field book after each of the farmer interviews, primarily in order to develop a greater understanding of the context of the individual – factors likely to impact, influence and direct the responses given by the individuals to the questions asked.

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[12] Interviews fall under the framework of the ARGOS ethics, which in turn have been accepted by the University of Otago Human Ethics Committee (approval number 05/035).

In all cases either transcripts or typed summaries of themed notes taken were either posted or emailed back to participants for verification. In one case, the recording instead of the transcript was returned. Participants were then phoned or emailed to discuss any modifications they felt necessary to the transcripts/ summaries and corrections to the original texts were made either over the phone or sent by email. Copies of the recordings and transcripts of HWW farmers (F1, F2 and F3) were lodged with HWW as resources to support both current and future research initiative

5.2.2 Grounded Theory

Grounded Theory (Glaser & Strauss, 1967) was used as the analytical method for this study. A basic list of preliminary codes was used to identify content that referred to the initial themes (Miles and Huberman 1994). A list of the codes used can be found in Appendix five. Coding was done by hand as the nature of documentation varied (full transcripts to thematic summaries). The process of reading and rereading transcripts/ summaries of interviews enabled a greater degree of familiarity and intimacy with the content, thus greatly facilitating the development of subsequent directions of inquiry. Emerging sub-themes were then further investigated either through further interviews and/or follow-up phone calls. The list of interview questions thus developed progressively, influenced by what emerged from the other interviews and through on-going analyses of interview content against available literature.

5.3 Results

The key themes to emerge from the farmer interviews are grouped in the following way: local knowledge which is "embedded" in the landscape; the closely linked experiential and experimental learning and the role intuition plays. These themes are not mutually exclusive, as knowledge can be defined in many different ways. Descriptions of the key information sources used by farmers in the course of their learning are found in Section 5.3.5.

5.3.1 Locally embedded knowledge

Locally embedded knowledge forms part of a common pool of information freely shared amongst farmers:

> *F2 Every farmer in the district says you can't put enough lime on…*

This knowledge belongs to the community, and is effectively "embedded" within it. As such, it is derived from collective experience, which has evolved and adapted agricultural methods over time to suit local conditions. In one of the regions in this study, traditional large-scale and low-input farming methods "…just… lots of acres to cover their cows rather than intensifying the farming…" (F2) appeared to preclude the necessity for formal soil testing. Locally available knowledge provided enough reliable information on which base soil input needs - though is only relevant if the farmer chooses a similar style of management.

The landscape itself is a repository of information and reveals layers of past land uses. Several of the study participants are descendants from many generations rooted in the same landscape while others do not have the same cultural and historic connection.

> *F1 …the old Māori communities and that around the district, that's what they'd do, they'd break new ground for their spud gardens every year, and that's what they'd target, was the Ribbonwood[13] country[…] I don't know what the Ribbonwood do to the ground or maybe it's what makes the Ribbonwood grow; must signal some sort of special nutrient or something that it gets out of there…*

In some cases, while traditional knowledge is still present it may exist in a non-verbal form, latent until the right conditions are established for its emergence; triggered perhaps by a comment from another person (J. Reid, Pers. Comm.)[14]. To illustrate this point, Grossman (2003) warns against reaching unwarranted conclusions when key words (identified by the researcher) do not surface. In Grossman's study, few farmers verbally acknowledged the process of decomposition, the word 'rot' being absent when describing compost. While

[13] *Plagianthus regius*

[14] John Reid, Project Manager, He Whenua Whakatipu (Lincoln). Phonecall October 17, 2005

decomposition would be obvious to farmers actively maintaining compost, Grossman concludes that this omission "…was most likely not due to a lack of observing the material's physical change, but possibly to a lack of vocabulary to describe the process". Thus while the knowledge may be present, the ability to verbalise the knowledge may not be. In some cases, though information was available, the significance of the information was not acknowledged until needed:

> *F3 it's good soil, what's down in there, the gardens of the past, there seems to be a microclimate in there […] these gardens you're going back 5 or 600 years plus [...] the gardens of the past [that] was told to me… I didn't realise it 'till I had a look a couple of years later…I was always told they were there but …either you want to look or you don't want to look… I was told and you can see and that's enough […] These are stories what are told by me, by people of the past, plus with Māori that was the way, it was said, it wasn't written, it was passed on that way, knowledge, most of the knowledge that Māori has, well it can't be questioned*

Excerpts such as this highlight the dynamic and at times fragile nature of knowledge and also raises what is described as a key difference in the way that local knowledge is constructed as distinct from scientific knowledge. In many local knowledge systems, knowledge and fact are uncontestable. Religious and supernatural explanations of phenomena within traditional knowledge systems are, by their nature, not open to questioning (Dickison 1994). Yet this excerpt is also open to interpretation as it not clear *who* should not be questioning this knowledge – the researcher as an outsider, any non-Māori, or any one at all Māori *and* non-Māori.

5.3.2 Learning through experience

On a basic level, the ecological response to a given activity exerts a strong influence on the feedback loop of experiential learning, a cycle which has informed farmers for millennia. This process can be simplified as: "farmer acts, ecosystem responds, farmer changes strategies" (Nerbonne and Lentz 2003). Farmers' predictive ability – in this case resulting from making a series of "adjustments" relies on their knowledge and understanding of local conditions, seasonality and natural processes (Röling 1994):

> *F5 …you get to know your property; what will last out into the dry period. Coming into the winter here, I know that the back of the property could run into a tight feed situation… it all depends on the weather; if it's a mild winter, snows 3 or 4 times between now and the shortest day… you just have to make adjustments.*

Learning by doing is still the most prevalent method of enhancing farming skills and occurs as a part of day-to-day practice (Hassanein and Kloppenberg 1995, Lyon 1996, Maarleveld and Dangbégnon 1999). This form of learning is continual with new methods trialled and evaluated as the need arises:

F5 … what I didn't know, I just sort of learnt – on the hoof…

In addition to direct experience, the observation of another's experience also provides a valuable opportunity for learning. Traditionally, this has taken the form of an "apprenticeship" with a farming family member (Fitzgerald 1993). As the farmer in the following excerpt explains, there is no need to question the motivation or rationale underlying the practices:

F1 …it was something we never ever talked about but we just followed [Dad] around, doing whatever he was doing, so we learnt by watching…

The importance of a long-term relationship to both the farm and surrounding landscape was clearly expressed in the farmer interviews and forms the basis of local or traditional environmental knowledge (Kloppenberg 1991). The majority of farmers interviewed for this study have resided on their farmland in excess of 30 years. "Knowing" your property and knowing how it will respond under certain conditions shows the temporal relationship to the land to be a crucial factor:

F6 …when we were up north, because we'd farmed up there all the time, you know exactly what to do, you know what's going to grow…

F5 You get a feel for the soil type… you get a feel for what it's going to do […] it's got to be honed by familiarity… longevity of experience and… just to know what's going on, on one part of the property I look at my rain gauge …it tells you a whole lot of things […] so that's not an intuiting thing, it's just knowing your property…

While farm management activities combined with context-specific feedback leads to the development over time of a body of local data, knowledge and wisdom which grows and becomes more finely tuned and responsive with each passing season (Röling 1994), the most detailed soil knowledge is likely to be in the areas most frequently used (Cools *et al.* 2003). Long-term observations gathered through varying climatic conditions are vital toward understanding longer-term soil-related processes such as drainage and water retention and the rate of crop/plant residue decomposition (Romig *et al.* 1995).

F7 …I don't know that much about [soil] but I do know to get a spade and what to look for

The above statement "…I don't know that much about soil…" was a frequent theme throughout the interviews and epitomises the difference between a knowledge based on technical terminology and science, and a "working" or experiential knowledge.

5.3.3 Learning through experimentation

At the heart of the paradigm shift which previously viewed innovations as developed by researchers and then disseminated to farmers (Rogers 1983), came the recognition that farmers themselves generate knowledge through their daily and seasonal decision-making processes as well as through active experimentation (Lyon 1996). Thus other forms of farmer learning centre on experimenting with new ideas and practices. These may be original ideas, or in some cases farmers may "re-invent the wheel" or adapt / customise ideas from others to suit their own contexts (Pretty 1995, Lyon 1996, Maarleveld and Dangbégnon 1999). A basic level of experimentation for example, may be described as: "…playing around a bit…" (F7), which clearly indicates the lack of formality attached to the process. It also suggests that the farmer is not heavily dependent on the outcomes, and is therefore willing to take a risk. Experiments may not always be planned; in some cases such as during adverse weather conditions the farmer is possibly left with no alternative but to try a new approach:

> *F1 if you turn the dirt up you gotta have the thing right to plant […] in this instance because we had such a bad wet spell […] there was no way we could get it dry enough to direct drill it so um we just blew the seed on straight out of the fert sprayer and um R. and I spent all night one night just harrowing, set of harrows dragging behind the tractor just shaking the seed down into the grass, bloody stuff worked a dream… we'd had 3 fine days, then it come in really warm drizzly northerly rain and it was really, really mild and I said to R. if anything's gonna grow, tonight's the night so we went for it, went all night […] and it worked perfectly…*

Taking a "trial and error" approach is a common form of farmer experimentation, with the success of the experiment determined by the outcome (Lyon 1996).

> *F6 …we read about [direct drilling], that's right… I read about it and I mentioned it to my neighbour… so he went and hired a drill and tried it on his place… his actually grew but he did the economy version… when we did our drilling we put some fertilizer in with it… took a couple of days but when it took off… yeah, his one's all gone, his one's history […] it never really grew.*

As adopting a new practice or product may entail considerable risk both in terms of time and economic cost, experimentation is crucial to determining local suitability:

> *F2 …local knowledge yeah that's how we got our grasses… the guys… [had] done some test plots and planted a paddock out in this, and that, and the other thing, and the best one that they'd come across, and the cheapest per acre was the Crusader grass, even if it didn't strike, it didn't matter because it didn't cost bugger all, but if it did then away she went…*

Lyon (1996) documented a wide range of farmer experiments in the UK such as the timing and dosage of chemicals as well as the use of agricultural machinery and novel crop varieties. Grossman (2003) argues that training and educating farmers to understand more difficult to see processes such as decomposition by micro-organisms is "especially valuable in encouraging farmers in their own experimentation" as farmers who do not grasp details of complex processes are also less likely to promote either their own or external research. Ryder (2003) however demonstrated that farmers in the Dominican Republic through experimenting with different varieties of crops were able to determine the suitability of soil in particular sites by observing which crop produced the highest yields. A key factor in Ryder's study was that many of the farmers were relatively new to the area therefore experimentation functioned as a critical tool not only for learning, but also for survival.

5.3.4 Farmer intuition

Intuition or instinct is integral to farmers' daily farm operation as it both guides and supports their decision-making. To some degree, intuition or instinct is also common sense. One farmer described his rationale for fencing some bush into each of the paddocks in the following way:

> *F1 …the cows really really suffer they'll go straight into that scrub for protection…that's just an instinct thing; that's nothing we've learnt from farming – you know how you feel in those situations, you wouldn't expect an animal to feel any different…*

Variously described as "just knowing" (Romig 1995), or just having a "hunch", intuition is a largely internal process and therefore remains largely inaccessible to observers (McCown 2002). The term intuition is therefore somewhat convenient, being widely used to describe the less tangible or less concretely verbalised aspects of farmers' activities. Nimmo (2005:110) for example describes farmers as "…farming intuitively with regard to monitoring, inputs and outputs". Nuthall and Bishop-Hurley (1995) combine intuition with mental-figuring and experience to describe what farmers in New Zealand rely on in order to facilitate complex decision-making. In Wilkinson's study of Hawke's Bay sheep and beef farmers, a small percentage of farmers (8%, n=112) soil tested in response to a "gut feeling" (Wilkinson 1996). Given the importance attributed to intuition in the decision-making process, it is worth probing a little deeper into the possible meanings, function and value of intuition for farmers. The following explanation reveals intuition in its broadest sense to be a highly detailed and individual form of knowledge, constructed from a complex array of information sources:

> *F5 …well I'd say that I didn't have that intuition for the first 10 years […] something you develop over time because of your closeness, your proximity, your continual involvement working with the land and obviously… your observations […] you tend to learn, and develop I think another sense about the property beyond what you can see, what you can measure in the traditional sort of way, it develops and I don't think it stops…*

Experiences gathered over time are integral to the development of a farmer's intuition. While intuition may develop in the course of many years spent on one property, equally the experience derived from years of working in different locations can also be absorbed, adapted and applied. As is described above, it seems that knowledge being both fluid and dynamic over time shifts from being conscious to being unconscious, automatic and internal. The value of intuition is that it is reliable and generally not open to question or doubt as other forms may be. Intuition doesn't need to be proven by other means, because it is just right:

> *F7 …I look at [the soil] myself, I start looking at compaction, drainage… then experience comes into to where you know why a paddock's suffering because you can just tell… you look at it visually – I wouldn't go and test it, I just know that it's not right.*

5.3.5 Sources of information for decision making

Knowledge also derives from the social location of the individual. Each of the means farmers use to develop their knowledge has its own specific social setting which exerts a strong influence on how the knowledge is regarded and acted upon (Bell 2004:15). For this reason, farmers were asked which sources of information they relied most strongly on, in other words which information they trusted most and thus based their management decisions on. This shows where key information derives from and highlights gaps in information extension when all of the potential sources are viewed together. Additionally, the most effective means of dissemination are revealed. The key sources of information used by farmers in this study are varied and are grouped as follows:

- Local networks
- Formal education
- Reading material (subscribed, unsubscribed and throw-aways)
- Discussion groups, farm advisors, industry representatives and field days
- Internet
- Regional council

5.3.5.1 Local networks

Local networks comprise the farmer's family and friends as well as immediate neighbours. Face to face communication with a trusted source known personally to the farmer was highly valued by all participants. Unfiltered through any form of media or external party, this was perceived as the most "direct way" of gathering information, and provided an "extra dimension" by virtue of the face-to-face contact.

> *F2 …oh we've had yaks with the odd farmer around the area [on] which is the best way to do things, when it comes to actually planting a crop we'll definitely be going to see those fellas and asking them, well what grew best for you?*

For some of the farmers in this study, the need to learn about agriculture was crucial for farm development:

> *F1 Well we haven't done a great deal of development... we haven't ploughed any ground, or worked any ground that's all sort of a new culture to us, and we're using people that have done stuff in the area, using them to give us a bit of a guide...*

"Looking over the fence", talking to neighbours as well as locals, all form part of an on-going and cumulative knowledge-building process and is central to farmer learning (Bradshaw and Williams 1998). Lobry de Bruyn and Abbey (2003) similarly found that information sources most valued by farmers in New South Wales (Australia) involved one-to-one contact between the farmer and a family member, neighbour or district agronomist. Where local networks are strong, farmers can benefit from the experience of others who have used and refined new methods to suit local conditions, cheaply and efficiently, thus mitigating the risk associated with adopting a new practice or product:

> *F1 ... its one thing to have the idea, the other thing is to have the confidence to have a crack at it, that's what I said about the mentoring thing, um, we use a network of people that we've known over a long time or got to know over a long period of time and um, with those sorts of things you can pretty much check things out to a reasonable degree, and mitigate some of the risk and that's what it's all about, it's about managing risk*

Bradshaw and Williams (1998) found that once farmers decided to adopt a new practice or technology, they typically use an extensive network of neighbours, representatives, vets and farm-related organisations to gather the information required. Furthermore, these networks are also used to check and validate the success of new management practices as Lyon (1996) also found in the UK. In the above excerpt, the farmer describes the value placed developing and maintaining a strong information network. An added bonus is that "word gets around gets around quickly" in local networks.

A vibrant local network is also the means toward accessing information well beyond what is available in the local community:

> *F2 ...I ask somebody not because he'll know, but [because] he might know somebody else that's in the industry...*

What the farmer doesn't say is that he is also likely to seek confirmation how useful and trustworthy these new and therefore "untested" sources may be.

Most of the farmers in this study grew up on farms, although some of the farmers described their family farms as "not well geared up" (F5) or a "hobby farm" (F1). Yet despite the dynamic nature of farming, past learning still informs current practice in terms of basic skills such as stockmanship:

> *F7 …back then it was only small herds... [180 cows] …more of a family affair…learnt from dad like how to calve a cow, mastitis, basic stock handling and feeding them, it's all still the same except that [now] it's on a bigger scale…*

The quality and relevance of information gleaned through other informal local networks such as pubs was generally not rated highly. Reasons for this included differing management practices from the farmer to other locals frequenting the pub, the difficulty of organising childcare as well as the farmers desire to simply talk about things other than work. Though information is freely passed around, it may not necessarily result in useful or new information:

> *F7 …yeah, [the pub's] not too bad; it's just how the cows are milking… just basic…*

> *F6 …now that I think about it; I'm with the [local volunteer] fire brigade you see and they're all farmers, the whole lot of them bar one… and they all talk about how their crops are doing and how their grasses are doing… so you sort of have a bit of networking there…*

5.3.5.2 Formal education

In three cases, farmers had undergone formal education, and though largely seen as a useful grounding, the practices learned required substantial modifications in order to suit local conditions. These farmers explain what formal education provided, and didn't provide:

> *F8 A lot of it was background information… you learnt about fertilizing, dry matter… the ins and outs of soil testing, we did a few […] It wasn't really through the course [National Certificate in Dairying], I picked that up just from listening to my old boss, taking it all in really, figuring it out for myself.*

> *F5 …it was a very ah, low-maintenance, low-input type farming dad was doing, yeah, we learnt some things but I learnt more when I went away and did training… 2 years…*

For both of these farmers, the technical information served different purposes and was correspondingly differently applied. The farmer in the first excerpt, by describing the technical information as "background" implies that it lacks applicability, and only through using a trusted source i.e. "my old boss" can the information be validated. In the second, the farmer is reliant on the technical information through not having a mentor to learn from. Formal education enabled the farmer to "get an understanding of the basics through practical work and exercises…" (F5). This learning could then be applied and adapted over time to suit local conditions. In some cases where technical information is presented to farmers, the lack of practical application may result in the information being retained though not fully understood (Grossman 2003):

> *F8 …if [the grass] is yellow, I think that could be because it doesn't have enough nitrogen in it? I think that's how it goes.*

5.3.5.3 Reading material, television and radio

Reference books were used by one farming couple "…when we first started farming" (F6). This implies that books of this nature have a limited lifespan of usefulness, in other words the reliance upon them lessens over time as the farmer develops methods more finely tuned to his/her local environment. Parminter *et al.* (1997) suggest that books are useful at the beginning stage of the learning process as content is often formulaic or prescriptive by nature:

> *F5 [when I first began farming] I tried to do things by the book I suppose… then you sort of ease off and then you start just applying your own particular way of doing things, and it becomes you…*

In light of the average number of years of farm experience in this study (approx. 30 years), it is therefore not surprising to find that magazines and newspapers were viewed primarily as supplementary information. Written sources of information were used primarily for comparisons with and ultimately confirmation of the farmers' own knowledge - as one farmer stated: "I don't run my farm off it, put it that way…"(F5)

> *F6 ...you only read what you are interested in... then you think oh, ...he's doing the wrong thing and you just ignore it see..... this guys doing an extra hundred kg's a hectare of beef than we are ,so you think, well, he's got a different type of cattle; there's plenty of different variables…*

Through mentioning different variables, the farmer shows that while some of the information may be of interest, an article alone provides too little real detail. Television and radio were not mentioned by the study participants. While media such as newspaper articles may *encourage* new methods as a study of East Coast (North Island) farmers by Andrew *et al.* (1997) showed, it is doubtful that an article alone would provide enough impetus for a farmer to change management practices - given the financial and environmental risks as well as farmers' emphasis on learning through action. Bradshaw and Williams (1998) found that many of the North Island farmers interviewed kept few published materials, preferring instead to obtain detailed information when they decided to take action.

5.3.5.4 Discussion groups, advisors, industry representatives and field days

Workshops and demonstration events function as useful methods of learning for farmers at the "competent" level. As the information provided is more pattern-focussed, the farmer is then able to recognise and deal with exceptions (Parminter *et al.* 1997:12). Formal group learning also represents an opportunity for farmers to learn the theory and principals underlying the use of certain management techniques, enabling more objective decision-making (Millar and Curtis 1999). In general, discussion groups were described by the farmers in the current study as providing the basis for "making good informed decisions" (F5). Farmers could benefit from the trials undertaken by other farmers in discussion groups, as one farmer explained:

> *F5 …these guys actually do it… [they] test the theories…*

In spite of the above view, only one farmer in the current study - managing a total of 4 farms, was actively involved with outside groups. While not necessarily providing the farmer with new information, the discussion group was still perceived as useful:

> *F7 [I go to] Field days; discussion groups – we have focus days; [the] farm advisor tells us what our targets are, which we know anyway, but just to reinforce...*

A range of reasons was put forward by the other farmers explaining why they did not join discussion groups, hire consultants or go to field days. Included was the likely change of land use with farm succession:

> *F5 …he in his time can do something with the property that perhaps I can't. The farm as it is at the moment won't sustain him through to his retirement, so he's got to find another way of utilising the land.*

Additional reasons included a lack of funds, physical isolation as well as having different farm management practices to those in the group:

> *F6 …totally different farming practices... [they] do things entirely different to what we do… we breakfeed all our cattle, and they feed all their cattle on a pad…just farming practices in general [are different], they sell a lot of hay and bailage, we don't really…*

5.3.5.5 Internet

Computers were not widely used by study participants for accessing agricultural information, though one farm manager described his reliance on the Internet for the following reasons:

> *F7 [I use the] Fonterra site... for production based stuff; milk quality… jobs; you can employ people off it, so I use the net quite a bit…*

Most of the farmers interviewed could see the potential of the Internet for providing locally relevant information:

> *F6 …at any stage we can get the information that's specific to our farm, but we have only recently got a computer so it is something that we could look at doing…*

> *F1 … at the moment my generation is probably struggling with [the Internet] but if you know the information is there, you'll get in there and find it and again it just helps your confidence, if you can really evaluate the situation of what you're trying to do, how you're trying to do it.*

Another farmer had recently purchased a computer and when queried whether they were going to access information specifically to do with farming replied "yep, that makes it tax-deductible!" F5. Regional councils including Environment South (Southland), Environment Canterbury, Otago Regional Council and Westland Regional Council all use the Internet as a means of disseminating soil related information such as informal on soil type and effluent disposal to land. However, it remains questionable as to how much the Internet actually influences farmers' management of their properties (Valentine *et al.* 2002). While there has been a significant uptake of the Internet in rural areas (Atkins 2000:22), on a national level, Māori in general are less likely than non-Māori to have personal computers or be involved in information technology training (TPK 2002:12).

5.3.5.6 Regional council

Despite the detailed local knowledge that farmers may have if they have been on their farms for longer time frames, farmers do require advice from external agencies with broader frames of reference as they themselves have a limited range outside their own farms to guide their decision-making (Cools *et al.* 2003). Regional Councils in New Zealand commonly address soil quality related issues through a range of educational programmes, farmer meetings and product endorsement in order to meet their stewardship requirements (Lilburne *et al.* 2002). However, the current emphases on soil related issues by regional councils vary considerably in line with the perceived pressures on the soil resource in their respective regions. In areas such as Westland for example, where dairying is replacing cattle farming coupled with the range of soil types found in the region, relatively little council generated information exists. In all, only one of the farmers in this study had had contact with a regional body through having a farm plan made in the 1970's[15]. Strongly focussed on soil conservation and land use capability (Blaschke and Ngapo 2003), the plan revealed 5 different types of soil on the

[15] Historically all catchment authorities in New Zealand were provided government subsidies to undertake environmental farm planning. In the late 1980's organisational changes through the implementation of the RMA resulted in a sharp decline of environmental farm planning. From the mid 1990's however, activity has increased and a greater diversity of farm plan types (e.g. riparian) have emerged (Blaschke and Ngapo, 2003).

farmer’s property. Instead of providing new information, the plan according to the farmer, “confirmed what I already knew” (F5).

5.4 Discussion

Locating the farmer within the respective hierarchies of social and ecological structures, underscores the contextual nature of knowledge construction, as this takes place *within* and *between* both arenas. The agro-ecosystem, as demonstrated in the diagram below, comprises interconnected social and ecological dimensions, and as such shows what can be termed “sites of learning”. Ecologically, the farmer is located on a farm within a watershed, which in turn is located within a network of other watersheds and eco-regions. Socially, the management choices made by the individual farmer are influenced by local farmer networks, which in turn are affected by the larger social, political and economic system (Nerbonne and Lentz 2003). As this diagram suggests, information sources can be divided into categories that reflect the potential distance to the end-user of the information. This distance, at once metaphorical and literal, was aptly demonstrated through the farmer interviews. Local networks i.e. the innermost sphere, were of greatest importance both for providing farmers with new information and for testing the veracity of this information. Far less use was made of information from more distant sources such from regional council level. Even if information was gathered from sources outside of the local community, it still had to be vetted through local sources.

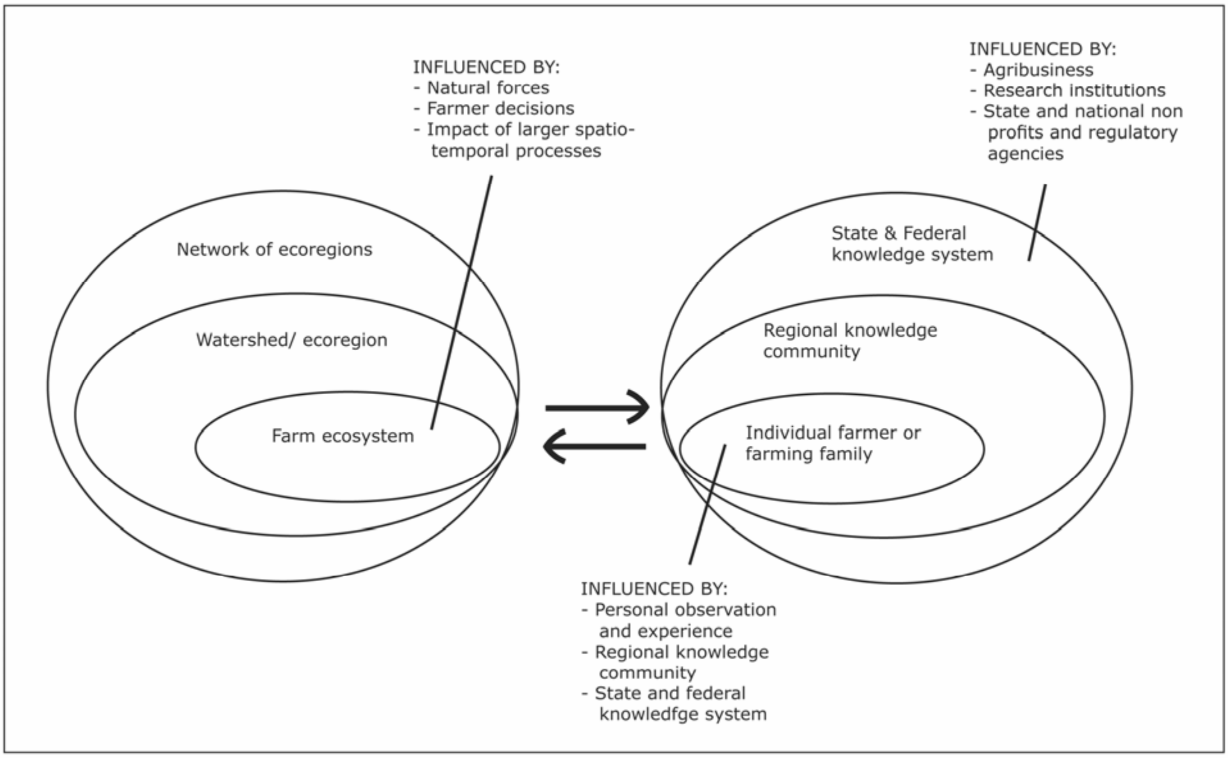

Fig. 4 The agro-ecosystem as a nested heirarchy. After Berkes and Folke 1998 (in Nerbonne and Lentz, 2003).

5.4.1 Farmer knowledge: attrition

Advances in technology coupled with demographic factors (which have seen herd sizes increase), farm ownership and farm succession impact on traditional/ local knowledge. Farmers' knowledge and abilities with regard to a particular activity may be eliminated through adopting new labour-saving technologies such as tractors and combines. These machines often required farmers to develop new sets of skills, while other skills are lost in the transition (Fitzgerald 1993, Tsouvalis *et al.* 2000). The dominance of technology to meet production increases has also resulted in significant social change with the emergence of a new breed of technically literate farmers, in effect "technicians" as opposed to the traditional farm hand (Tsouvalis *et al.* 2000). Changes in farm ownership may result in a loss of locally accumulated knowledge as the farmer moves to a new location, although new knowledge may be "imported". This may take the form of an alternative management style, though while potentially expanding the local knowledge pool may not be absorbed due to the formidable barrier of locally held traditions. Farm succession also emerges as a key issue - not only impacting on the social fabric of the family (Hunt *et al.* 2006), but also potentially resulting in a loss of accumulated family knowledge.

5.4.2 Farmer knowledge: growth

Farmer knowledge accumulation is undoubtedly complex and takes many interrelated forms. Experimentation for example, has previously been the subject of much literature focussed on developing countries (e.g. Okali *et al.* 1994). However, integrating experimentation into day-to-day practices counters the claim that farmers in developed countries with access to high quality research and extension reduces the need and willingness to experiment and use locally derived knowledge (Lyon 1996). In other countries such as Australia and U.S.A., direct experimentation is used by farmers to develop innovative approaches to pasture management (Hassanein and Kloppenberg 1995, Millar and Curtis 1999). Experimentation as the farmer interviews in the current study show, occurs on a wide range of scales and with differing degrees of rigour, in other words, range from side by side trials (though characteristically without any replication) to "happy accidents". The majority of what farmers appear to do in terms of farm management follows two main approaches. These are evolutionary learning through using trial and error approaches and passive-adaptive approaches. In the former, initial choices may be haphazard whereas later choices are derived from a subset of activities which resulted in desired outcomes. The latter passive-adaptive approach relies on historical data where decisions are based on the past performance of for example a management activity (Walters 1986 in Walters and Holling 1990). The latter is also an effective strategy for managing risk, as the approach has been proven to work. These approaches are relevant to the scale at which the farmers operate, i.e.

predominantly at the farm as opposed to catchment level. A limitation however of this approach is that it may lock farmers into patterns based on tradition as this excerpt demonstrates:

> *F6 …the neighbour over here, he was horrified when he saw how little our paddocks were… he's got a thousand odd acres and he's only got about 20 paddocks… [we've put in] 42 on 200-odd acres from 6 when we first came here*
>
> MP So do you think that people are learning things from you guys?
>
> *F6 no, they're set in their ways down here... their grandfather did it and their father did it…*

Tradition serves to protect and ensure the continuation of practices which have proven to be reliable and successful over extended timeframes. New and therefore unproven alternative practices do not carry the same weight. Farmers may be reluctant to set aside their traditional methods despite possible inefficiency: "Served them well so, they can't see any reason to change…" (F1) and thus may prevent the uptake of more effective practices. (Further barriers to adopting new practices and technologies are discussed in Chapter 6).

While some of what farmers do may be classed as "re-inventing the wheel" (Lyon 1996), the process of building new knowledge is enhanced through farmers having access to wider sources of information to experiment with, discard, absorb or modify to suit their needs. The NZ Ministry for the Environment (MfE 1994) therefore recognises that *information generation* and *social participation* (emphases my own) are key conditions toward achieving its vision of "a clean, healthy and unique environment, sustaining nature and peoples' needs and aspirations". This statement broadly implies that sustainability is an outcome of combining these key criteria. Given the dominance of agriculture in New Zealand's landscape and the increasing emphasis on "sustainable land use", examining these two conditions in more detail provides further insights into the where and how of farmer learning and knowledge.

5.4.3 Information generation

Access to good information is vital if farmers are to take up the challenge of developing novel approaches to managing their land sustainably (Bradshaw and Williams 1998:2). Bradshaw and Williams (1998:16) note that farmers while receiving large amounts of written materials, generally do not keep much (least of all un-subscribed materials) preferring instead to seek specific information when required for new products and activities. Both Parminter *et al.* (1997) and Valentine *et al.* (2002) stress the need for much of the information produced to be "repackaged" in order to better meet farmers' needs. Overly academic or theoretical information which does not relate easily to practice will not reach the intended audience, and thus has limited applicability. Some farmers may reject the information - not because they disagree with the content as such, but object to the way the information is presented (Schenk *et al.* 2006). Repackaging also requires the information to be culturally appropriate to the community. As the key decision-makers, the community ultimately governs how this information is used, and whether or not it is used at all (Moller 2001). Information on sustainable resource management therefore should be presented in ways which make use of the problem solving skills farmers already have while also supporting their desire to be independent decision-makers (Parminter *et al.* 1997).

There is however, no apparent shortage of information generation. As Nerbonne and Lentz (2003) wryly comment the science response to issues such as soil degradation is to create yet more information despite little of it effectively reaching the proposed end user. In this sense the issue is less one of information generation than one of effective information dissemination. A crucial factor missing from much agricultural research is communication between researchers and end user, and this also suggests that the reverse, i.e. information moving from end-user to researcher, is similarly missing. Information moving in the latter way also suggests a reversal from “top down” to “bottom up”. How is this to be achieved? There are significant gaps in the way that information moves between actors in the agro-ecological system. On an industry level for example, farmers are conspicuously absent in the development process for precision-farming technologies in Britain (Tsouvalis *et al.* 2000). In New Zealand a lack of effective communication has hindered stakeholder input into decision-making processes for environmental policy development (PCE 2004b) in all likelihood strengthening the destructive rural-urban “us” and “them” divide.

5.4.4 Social participation

There is a general consensus within agricultural discourse that a democratisation of decision-making is a prerequisite for sustainable development (e.g. Pretty 1995, Thompson and Scoones 1994, Sumberg *et al.* 2003). Harmsworth (2004) among other many authors highlights the need for full involvement of *all* stakeholders along with sufficient representation of their views and perspectives in order to create the conditions required for effective change.

The increasing emphasis on sites of co-learning such as workshops, focus groups and field days within the agriculture sector (Bloomer 2001, Millar and Curtis 1999, Andrew *et al.* 1997) confirms that knowledge building is a social process, emerging from interaction and dialogue between different people, networks, and communities (Scoones and Thompson 1994). Multi-stakeholder participation has thus become the dominant paradigm guiding contemporary research and extension practices (Sumberg *et al.* 2003). This approach is understandable given the domination (and deficiencies) of the adoption-diffusion or Transfer of Technology (TOT) model (Rogers 1983) which has underpinned agricultural extension for 50 years (Sumberg *et al.* 2003). In this linear model, innovations developed by technical specialists are adopted (through agricultural extensionists) by farmers then diffused through local networks. Farmers were categorised according to their likelihood of adopting a new technology based on factors such as education, farm size, income, social status and so forth[16]. Farmers were thus seen as the passive "receivers" of technical innovations developed by scientists (Raedeke and Rikoon 1997). The assumption here is that cutting-edge ideas are developed in places such as universities, thus justifying the use of a top-down, researcher-led approach (Bell 2004:172).

The TOT model grossly oversimplifies the complexities not only inherent within the whole social sphere of the agro-ecosystem, but also in the ways that information ebbs and flows, is built up, spread out, lost, re-discovered and continually adapted over time to suit individual contexts. As the MfE (1994) states, social participation is a cornerstone of sustainable development, and this is precisely what is missing from the TOT model. Social participation, as defined by Pretty (1995) comprises "…a structural methodology based on principals of multiple perspectives, group inquiry, context specificity, and flexibility that uses systematic methods to bring about changes in problem situations that people in the situations see as improvements." While farmers may "participate" in a questionnaire, participation in its truest sense describes an on-going process. Participation however, is not a single event in time such as consultation though both terms are still frequently confused (Allen *et al.* 2002:29). There is however a large gap firstly between having access to, and secondly being able to participate in, the various "forums" where learning, and ultimately knowledge-building can occur.

5.4.5 Sites of co-learning

Group situations with scientists / technical experts present can create challenges as farmers present may be unwilling to contribute their knowledge and experience when unfamiliar with, and potentially intimidated by scientific jargon (Millar and Curtis 1998). Given that trust plays such an important role in vetting information sources (highlighted by the farmers in this and other studies e.g. Bradshaw and Williams 1998, Lobrey de Bruyn and Abbey 2003, Nerbonne and Lentz 2003), this factor may affect the type and depth of knowledge that farmers may share with others in an unfamiliar group situations. Further complexity is added when cultural

[16] To account for uneven uptake, farmers were categorised from "Innovators" or "Early adopters" through to "Laggards", the idea being that the laggardly farmers would be the least likely group to make use of the newly developed technologies.

factors are taken into consideration. Māori farmers for example, are often underrepresented at field days and demonstrations (Andrew *et al.* 1997). Despite these events being rated highly by Māori in terms of encouraging sustainable management practices, Māori farmers have felt more isolated from support from other Māori as well as from the dairy industry (Clough u.d.). One of the underlying reasons relates to the different methods of group learning that take place within Māori culture, which uses hui as a forum for information extension and exchange. Hui, as gatherings are transparent in process, output and outcome (Wedderburn *et al.* 2004). Furthermore they are bound by strict protocol, procedures though "… steeped in metaphoric meanings" are also "…highly effective in dealing with contemporary issues and concerns of all kinds" (Bishop 1996:34). Thus the recent development of discussion groups specifically aimed at Māori farmers are cemented on cultural values such as *Whakakotahitanga* (respect for individual differences and the desire to reach consensus), *Kaitiakitanga* (stewardship), *Whanaungatanga* (togetherness, relatedness) and *Mana Whenua* (customary authority) while incorporating *Mahi haere ahuwhenua* (commerical viability) (Clough u.d.). Combined, these values simultaneously form the foundation for, and means toward knowledge construction and with this, empowerment. The outcome of one such group based in the Hawke's Bay region was the creation of a caring and supportive culture, which enabled the farmers to describe their situation honestly in an environment where it was safe to do so (Clough u.d.). While several of the farmers in this study mentioned begin a part of a discussion group, none of took part in forums designed specifically to connect Māori culture to agricultural practices as was described above. Roskruge (1999a) argues that contemporary Māori agriculture and horticulture are "virtually non-existent" as a separate identity, yet this study highlights very clearly that a differences persist in the way that Māori farmers relate to their farmscapes. While not necessarily manifested in routine day-to-day activities (and not necessarily revealed through the interview process), culture plays a strong part in determining broader management decisions underpinning the farm as a whole. The existence of culturally focused farmer discussion groups, though highly dependent on population density, is proof that traditional Māori values are still pertinent and able to provide a solid foundation for contemporary agricultural practices. Importantly, this initiative also demonstrates the positive outcomes of bottom-up initiatives.

5.5 Conclusion

This study of diverse individuals clearly demonstrates the dynamic and context dependent nature of knowledge where background experience, values and personal aspirations are critical factors in shaping the outlook of each farmer. Farmer methods of learning are diverse, and range from conscious activities to on-going observations of cause and effect which are tightly woven to the landscape. In this respect, the distinction between experiential learning and experimental learning are blurred. For the researcher, gauging farmer knowledge through the use of particular words can be misleading as there are many factors which influence the farmers' vocabulary let alone the ways in which the farmers choose to express themselves. Additionally, much of the farmer's knowledge may be embedded within actions, many largely automatic as they form part of normal daily or seasonal practices.

Arguably there is easy access to information in N.Z. through a combination of factors including a high level of literacy[17], access to communication technology and a relative lack of physical isolation. As agriculture makes up a significant portion of the New Zealand economy, there is a strong supporting network and thus a range of potential information providers, which include local government, industry, research providers and farmer lobby groups. In spite of this the most useful, rich, trusted source of information was found locally to each farmer as the reliance on other forms of information diminished rapidly in tandem with the physical distance of the source from the farmer. While there are two key ingredients for sustainable development – information generation and social participation, the latter is still lacking particularly for Māori farmers. The emphasis here should be on creating further forums, as the successful Clough example shows, which fuse traditional values with contemporary needs. These forums also support farmers' preference for face-to-face information exchange as opposed to receiving more written information which may lack local applicability. Participation is a widely used term and should however not be seen as a simple "fix" in the same way that society may view technology as a "fix" for environmental issues. Participation is a strategic process whereby decision-making becomes a democratic process. An area that warrants further research is the dynamic between farmer knowledge attrition and growth particularly given the rapid pace of change in the agricultural sector.

[17] New Zealand's adult literacy rate (above 15 years) is 99% (Thomson and Tunnah 2003)

6 METHODS FOR MONITORING SOIL QUALITY: A CASE OF CONTRASTS

6.1 Introduction

If monitoring to a scientist is defined as the systematic measurement of variables and processes over time, carried out in such a way as to ensure comparability of temporally separated data (Spellerberg 1991), what then does monitoring mean to a farmer? While monitoring defines a specific set of processes to a scientist the same activity may be understood and carried out very differently by a farmer. There are a wide range of “tools” available to the farmer for assessing trends in SQ over time. These tools range from laboratory based tests, where data are typically collected by consultants or industry representatives, to simple kits used by the farmers themselves on farm. Other approaches farmers may use to monitor SQ are more subtle: less one of a conscious activity using a structured framework, than one of an automatic appraisal in the course of daily and seasonal activities (Wilkinson 1996).

Investigating the methods farmers use to monitoring the quality of their soils over time is important, as soil degradation carries not only socio-economic consequences but also significant environmental consequences. Understanding the farmers’ rationale for favouring certain approaches over others means probing a wide range of socio-cultural factors which contribute to individual decision-making. Gaining an insight into these factors will ultimately assist with determining the barriers and opportunities facing farmers in relation to adopting novel technologies into their farming operations. The latter theme, first explored in the 1950’s has continued to increase in relevance in tandem with the need for farmers to find effective ways of meeting rising costs and increased demands for productivity (Rogers 1983, PCE 2004a).

The importance of investigating farmer methods can be better understood when viewed within the broader context of the regulatory frameworks governing the agricultural sector. Soil quality lies under the Resource Management Act (RMA) (New Zealand Government 1991)[18] which is the legislative framework promoting the sustainable management of both natural and physical resources. As the RMA does not specify how sustainable resource use should be achieved, the 17 autonomous local authorities are charged with implementing the Act. Many however, are still debating whether to take a regulatory approach to land practices which impact on soil

[18] The Act promotes the sustainable management through “…safeguarding the life-supporting capacity of air, water, soil and ecosystems, and by avoiding, remedying, or mitigating any adverse effects of activities on the environment” (RMA 1991, Part II: Section 5).

quality (Lilburne *et al.* 2002, Blaschke and Ngapo 2003) and thus rely predominantly on voluntary approaches by farmers to look after their soil resources (PCE 2004a: 172).

The objective of this chapter therefore is to investigate the range of methods used by farmers to monitor the condition of their soil. While the emphasis of Chapter 4 lay in examining the types of indicators used regularly by farmers the emphasis in this chapter lies more firmly on what type of “decision - making systems” these indicators are incorporated into.

6.2 Methods

Semi-structured interviews[19] with 8 Māori pastoral farmers and family members who played a key role in farming operations began in February 2005 (summer) and continued until September 2005 (late winter). All interviews were conducted face-to-face either in the participants' home or while (literally) in the field, in the course of carrying out farm management activities. Interview length ranged from approximately 1 hour to most of the day dependent on the availability of participant and other factors such as the number of people present (e.g. other HWW and ARGOS staff) and location of the interview. As it was not feasible to re-interview all of the study participants, those selected for follow-up interviews were farmers currently linked to the HWW sustainable development programme. These interviews were carried out 4-6 weeks apart and covered similarly varied amounts of time.

Relevant Regional and District Council staff, agricultural consultants and soil scientists were also contacted and mined for their technical expertise as well as to discuss their experiences of communicating with farmers in different parts of New Zealand. These interviews either face to face or over the telephone, were loosely structured comprising a mixture of open and closed questions and were documented as themes in a field book. By mutual agreement between myself and the interviewees, no post-interview verification of the notes taken was seen as necessary in light of the highly informal nature of communications.

6.2.1 Interview documentation

Interviews were documented by tape recording, and notes taken during and after interviews. The desire of the participant combined with the nature of communication dictated the form of interview documentation. In some cases, interviews were tape-recorded or notes were made directly into a field book during interviews. In other cases, for example during preliminary meetings with participants or where interviews developed into wide-ranging conversations, tape recording was considered inappropriate. Here, the main themes emerging over the course of the day were summarised afterwards in a field book. Summaries were crosschecked with the other researchers that had been present to ensure all relevant information was included. Informal observational notes were also recorded in a field book after each of the farmer interviews, primarily in order to develop a greater understanding of the context of the individual – factors likely to impact, influence and direct the responses given by the individuals to the questions asked.

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[19] Interviews fall under the framework of the ARGOS ethics, which in turn have been accepted by the University of Otago Human Ethics Committee (approval number 05/035).

In all cases either transcripts or typed summaries of themed notes taken were either posted or emailed back to participants for verification. In one case, the recording instead of the transcript was returned. Participants were then phoned or emailed to discuss any modifications they felt necessary to the transcripts/ summaries and corrections to the original texts were made either over the phone or sent by email. Copies of the recordings and transcripts of HWW farmers (F1, F2 and F3) were lodged with HWW as resources to support both current and future research initiative

6.2.2 Grounded Theory

Grounded Theory (Glaser & Strauss, 1967) was used as the analytical method for this study. A basic list of preliminary codes was used to identify content that referred to the initial themes (Miles and Huberman 1994). A list of the codes used can be found in Appendix five. Coding was done by hand as the nature of documentation varied (full transcripts to thematic summaries). The process of reading and rereading transcripts/ summaries of interviews enabled a greater degree of familiarity and intimacy with the content, thus greatly facilitating the development of subsequent directions of inquiry. Emerging sub-themes were then further investigated either through further interviews and/or follow-up phone calls. The list of interview questions thus developed progressively, influenced by what emerged from the other interviews and through on-going analyses of interview content against available literature.

6.3 Results

For the purposes of this study, resource monitoring by farmers is divided into 2 groups, namely formal and informal methods. Differences in the two approaches are highlighted through the manner of collection, documentation and storage of data, along with the different kinds of information drawn from the data (Wilkinson 1996, Bloomer 2002). Undoubtedly there is also a difference in the level of complexity in so far as the former is a structured activity bound by protocol, while the latter owes its complexity to the socio-cultural diversity of the individual farmers and their locations in the landscape.

6.3.1 Informal monitoring

Informal or subjective monitoring, though seemingly *ad hoc,* warrants closer examination as it forms part of farmers' day to day and seasonal processes for assessing resource condition. Typically multivariate, informal monitoring comprises a range of factors such as pasture colour in conjunction with sward thickness and species composition (Gray 2005). While an integral part of the farming operation few farmers would use the term "monitoring" to describe what they do, and considerable prompting may be required in order for farmers to explain exactly what they do and how they go about it (Wilkinson 1996). Thus to gain an understanding of the informal methods a farmer regularly uses, the underlying and largely observational processes which form part of the farmers' store of tacit knowledge needs to be brought to light. It is clear that a great deal of information is gleaned by farmers through their informal observations. This information however, stays in the farmers' head and as such is not documented, let alone articulated. Appraisal of farm condition is what a good farmer does as a matter of course, "…they no longer have to think about it, they just do it" (Wilkinson 1996).

The informal monitoring methods used by the farmers in this study are highly diverse, and for the most part centre on cumulative observations of phenomena over extended time frames. In this sense there is no real distinction between "just looking" and casual resource appraisal as the latter occurs automatically in the course of just looking. The strength of these appraisals for most of the farmers in this study lies in an intimate understanding of the local conditions on their farms - an understanding which has grown over many years. For others, observations in the course of farming in different locations provided a larger knowledge base from which to draw on:

> *F7 …where we were, it was an ash-type soil… it was quite powdery if you chewed the grass off, it just left dirt; when the wind blows, it just blew most of it away…when the wind blows here […] the soil doesn't tend to blow away […] if it gets really dry and get a bit of wind you see a bit of dust blowing around, that's all.*

Informal monitoring in its richest and most integrated sense occurs in the course of carrying out day-to-day activities, such as digging holes for fence posts and making farm tracks. The informality of the process is echoed in the language used to describe the activities, with farmers in this study describing their methods of informally assessing soil quality as, for example "taking a slice out a bank" (F4) or just "having a bit of a dig around" (F7). Bloomer (2001) describes "walking the paddocks" as a frequent occurrence by both Heretaunga and Ruataniwha farmers in order to both observe their soils as well as gauge the level of compaction. Lobrey de Bruyn and Abbey (2003) mention Australian farmers "kicking the dirt" to see whether it sticks to the boot as a measure of soil moisture content. While these processes centre on the soil itself, a characteristic feature of informal monitoring lies in the use of "proxy" or indirect measures (Gray 2005). This type of measure is characteristic of informal monitoring methods and, as revealed in the previous chapter, forms an important part of the farmers' suite of indicators. Informal methods based for example, on the visual appraisal of dry matter in the paddock underpin broader management decisions such as when to move stock (Bennett *et al.* 1999). A further example is the between-year comparison of production. As this information remains largely un-documented the farmer is reliant on his/her memory for establishing benchmarks:

> *F5 … because you've got stock growing off that land all the time so, so they're coming off good, bad…*

Further use of comparative measures occurs for example, in travelling from one place to another within the same locality. This provides an opportunity for the farmer to compare management strategies, thus effectively using the performance of a neighbouring farm as a benchmark from which to gauge his own farm performance:

> *F7 …I get a lot out of visual if I'm driving to one of the runoff's or going somewhere, see what someone's doing, how he's doing it, it's normally in the same sort of ball park…*

By describing the other farm as being in the "same sort of ball-park", the farmer is able to validate his own observations through the knowledge that the other farmer runs a similar operation on a similar soil type. Furthermore, these casual observations also function to supplement learning, as both farmers are likely to face similar issues in relation to limiting factors inherent in the resource base.

6.3.2 Formal monitoring

By contrast to informal methods, formal methods typically require specialised equipment as well as the technical expertise required to use the equipment. In addition, formal methods are replicable and follow standardised procedures. The maintenance of soil fertility is an essential component of sustainable land use as examining trends in soil fertility over time can show whether the land management is increasing, maintaining or depleting soil nutrients (Wheeler *et al.* 2004). Thus one of the key approaches to quantifying the nutrient status of the soil is the soil test. To measure soil fertility, standardised nutrient tests are used which provide the farmer with numerical or percent values against established benchmarks for land use and soil types (Gray 2005). The primary function of a soil test is to identify the amount of corrective action required to build or maintain soil fertility "…just to see what [the soil] needs to get it up to maximum grass growth…" (F6). Soil testing by professionals was the most common method of formal assessment relied on by farmers in this study, though was carried out with varying levels of frequency as Table 4 (overleaf) shows. The use of soil tests serves to regulate the amount of fertiliser used, thus avoiding both under or over-application:

> *F6 …the neighbour up there never got any soil tests and he put on 5 ton of lime and 600 kg's of super, he put on probably 4 or 5 times the amount we put on and yet his grass was no different to ours…*

Formal soil testing can also function as a tool to supplement and enhance learning:

> *F1 …but the likes of cultivating new land and growing new grasses and fertiliser and those sorts of things that was something we've never ever done here, so those sorts of skills are something we need […] doing your soil samples because what [the other farmers] do on the seat of their pants, these soil samples will tell us exactly what we gotta do…*

One farmer in this study described the function of a soil test to both to confirm his own informal assessment and to provide an objective assessment of a "hunch" or "feeling":

> *F7 …we…sort of had a hunch about what's going on there, but we have been tripped up before where the grass mix… but the soil tests were fine… wrong grass mix; that's another thing*

This suggests that while the objectivity is valued, it does not function as a replacement of the farmers' informal observations. Instead, the validity of the initial informal assessment is strengthened. While formal and informal methods provide the farmer with correspondingly different information, Wilkinson (1996) stresses that farmers base their decision-making on *information* not *data*. In this sense, the data as derived from soil tests, must first be integrated with information before it becomes useful for making management decisions. This interdependent use of formal and informal measures is demonstrated in the excerpt below, which describes an intensively managed dairying operation:

> *F7 …when I see [the soil test results], I also do biops on the cows, magnesium's really important for the cows, so if I see the magnesium on the farm down on the soil results, I'll do a biops… anything that you want to put through the soil's long term, same with selenium… so rather than just [look at] the soil, we look at the cow, because that's what she does, she eats it… because we understand cows more than soil.*

Though effectively using a proxy measure, i.e. the cow, the farmer has integrated a range of formal measures which are verified through a system of cross-checks.

6.3.3 Soil testing frequency

There is general acknowledgement by farmers that there is a need for SQ and water to be better monitored (Hunt *et al.* 2006:30). National figures however show that only 19% of dairy farmers formally test their soils (Anon 2005: 2). In the current study, the frequency of soil testing was linked to the scale and intensity of farming operations – Wilkinson (1996) likewise finding that farmers who used a lot of fertiliser and drench were more likely to carry out formal monitoring.

Table 4. Farmer soil testing frequency

FARMER	FREQUENCY	REASONS
F1, F2	No, never	Future aim*
F3	No, never	Future aim*
F4	"sporadically"	Environmental and economic
F5	Once (2004)	Environmental and economic
F6	Regularly/ as required	Understanding local fertilizer needs for new farm
F7	Regularly/ as required	Developing a fertiliser plan and to meet production goals
F8	N/A	As farm employee, not responsible for soil testing

* Farmers are part of the He Whenua Whakatipu (HWW) sustainable development programme – see Appendix for further detail. HWW aims to carry out regularly soil testing to assess the effects of differing management strategies on pastures.

For one farmer, the need to reach production goals within specific time frames necessitated the use of rapid, repeatable and standardised methods:

> *F7 …my position on this farm is to drive the farm forward, maximise returns… milk in the vat […] Instead of being one-on-one with all this soil stuff… we don't have the time, we ring up the expert, [they] come in, tell me what we should do, match it up, bang, go and do it, churn-and-burn, that's about it.*

The farmers interviewed in this study generally used standard soil tests as a tactical measure to define the amount of fertiliser needed. Soil testing as such was not used as a tool to specifically seek longer-term trends and problems. In a study of Manawatu farmers carried out by Bennett *et al.* (1999), half were using soil tests to monitor soil fertility levels (50%, n=14) while Wilkinson (1996) found a small majority of Hawkes Bay farmers used soil testing for strategic purposes, i.e. using it to set a fertiliser policy (58%, n=115). In the Gisborne and

Wairoa districts(East Coast) Andrew *et al.* (1997) found that while 80% of respondents (n=49) indicated they would soil test in order develop a fertiliser plan, the cost of soil testing was cited as a deciding factor. In addition, some of the farmers did not see the need to test, as they already knew that they weren't using enough fertiliser - in other words the farmers did not need to be told what they already knew. This is echoed in the current study:

> *F2 …no need to [soil test], everyone knows that they need lime and that's about all, that's about as far as it goes down here*

While the above shows that farmers have a strong awareness of pH, a widely used SQ (Bennett *et al.* 1998), it also suggests that other nutrients are either not regarded as limiting or are not commonly thought of, or known. It is also possible that further testing is not regarded as necessary for the type of farm management used in the region.

6.3.4 Use and misuse of formal methods

As pastoral farming results in a loss of nutrients from the farm soils, deficiencies can develop over time (Kemp *et al.* 2002). Interviews however with farm consultants and fertiliser representatives[20] reveal that soil testing is largely guided by pragmatism - cost and time surfacing as key factors.

Critical areas such as effluent blocks are usually tested, though on larger properties only a few sites are typically selected. The lack of replication, or if only a few assessment sites are sampled could result in misdiagnosis, i.e. the under or over application of nutrients (Sojka *et al.* 2003). Variability for example, between areas in grazed pastures is particularly strong as nutrients from animal dung and urine are returned unevenly to the soil (Cornforth 1998: 100). Farmers in the Manawatu on average tested only 23% of their land annually, or approximately 4 paddocks (Bennett *et al.* 1998). In the current study, soil tests were usually limited to the areas specified by the farmer – where the farmer suspects there is a problem:

> *F6 …where the grass just wasn't doing that well…*

> *F7 … [the fertiliser representatives] come out every year I'll take them to the poorer paddocks… for us its just grass growth, that's the game we're in.*

There are significant issues with a problem-focused approach to soil testing as longer-term declines are masked. These declines may not be highly visible and an issue here may be that without formal quantification, there are no benchmarks from which to operate. Mg values for instance appear to have decreased nationally on intensive dairy farms with outputs exceeding

[20] Jan Derks, Farm Consultant (Hari Hari); Rex Dolby, AgroScience Consulting Services (Dunedin); Peter Ayres, Technical Sales Representative, Fertiliser (East Taieri), Peter Singleton, Environment Waikato (Hamilton)

inputs (Wheeler *et al.* 2004). However despite the significant cost of inputs, over-application of nutrients is also an issue. According to Environment Waikato[21] (a local authority) many pasture soils in the Waikato Region are over-fertilised with Olsen P values exceeding the upper limit of the range for near maximum pasture production (Morton *et al.* 2003, in Wheeler *et al.* 2004). Dolby (Pers. Comm.)[22] describes this as "fertilizing for the future" a mistaken perception whereby higher P inputs are seen to be building up the stores of available phosphorus (P). Similarly quantity issues occur with nitrogen, where under use will affect productivity, and overuse runs the risk of leaching into groundwater and ultimately surface waterways where eutrophication can occur (Valentine and Kemp 2002).

[21] http://www.ew.govt.nz/enviroinfo/land/management/nutrients/phosphorus.htm#Heading4

[22] Dr. Rex Dolby. AgroScience Consulting Services (Dunedin) Phonecall May 26, 2005; interview June 3, 2006

6.4 Discussion

There is a complex range of reasons influencing a farmer's decision on which types of SQ monitoring to use. In order to examine these influences, it is necessary to broaden the context to include both collective and personal cultural values. The nature of the relationship between the farmer and the land - whether manager, employee, farm lessee and/or part owner within multiply owned blocks of Māori land has direct implications in terms of farm management – especially the latter (TPK 2002:52)[23]. The farmers' relationship to the land however is rarely expressly researched in other soil health related investigations. Although Roskruge (1999a) argues that little difference exists between contemporary Māori and non- Māori agriculture, the way in which the indigenous relationship to the land is expressed highlights a distinctive worldview. For one of the farmers in the current study, cultural difference was expressed in the following way:

> *F5 …another feature I think is that [Māori farmers] tended to leave more bush on the property than other, European farmers […] I put that down to the fact as well that they… didn't seek to turn every single possible cent out of the ground, [they were a] bit more relaxed about their approach.*

The relationship to the land and the "…more relaxed approach" taken by the farmers in this study who either farm close to or on whānau land is clearly articulated:

> *F5 …with long association and having other forms of relationships with the landscape […] the longer you find people have been established in a country the more – this is just an observation of mine – the more relaxed they are about those sort of things, you see what I'm saying?*

The study participants' view of soil health can be understood as being inextricably bound to concerns for environmental health while being heavily influenced by economic uncertainty or pressure. The tension these twin objectives create for the farmer are clearly stated:

> *F4 …trying to provide more of balance between economic objectives and a sustainable environment […] our place, the farm is to the extent where there is barely a native tree on it, so I guess […] I got side-tracked along the way because of the economics of the situation, creates it's own constraints […]*

For several of the farmers, just to retain their land in the face of economic hardship has presented considerable challenges, let alone finding the means to develop the land in order to improve productivity:

> *F3 …you have to have money to put lime on the ground and to bring your levels up to that production yes, but it costs. You have to have the money first. […] I've put no foreign fertilisers on the land since I've had it… poverty possibly part of it!*

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[23] For an outline of the key legislation impacting on Māori and agriculture, see Appendix 3.

Further reasons for the low use of fertiliser among Māori stem from cultural beliefs: the concept of using any form of fertiliser sourced from animal, human or food waste – especially in relation to crops, was and still is offensive to Māori beliefs (Roskruge 1999b). Historically wood ash was used to increase soil fertility, and while manufactured fertilisers are now commonplace, many Māori are still wary of their origins (Roskruge 1999b).

6.4.1 Inputs: environmental costs

While maximum productivity was stated as an aim by one of the participants managing several farms (F7), other farmers in this study - as either owner/operators and/or lessees of multiples stakeholder land - discussed soil testing (actual and future potential) against the backdrop of costs to the environment. Formal soil tests provided farmers with a means toward lowering fertilizer inputs and therefore minimizing nutrient leaching into groundwater or occurring as run-off. This was a strongly voiced concern for farmers where water sources were such as wetlands and rivers/ streams were on-farm or nearby or where the farm was located near the coast. As a self-described “caretaker”, one of the farmers (F3), in referring to the river running through the property as an “artery” clearly acknowledges the life-supporting function of the water. On both of the large, multiply-owned blocks harvesting resources from the land is an intrinsic right grounded in the historical relationship to the land. On-farm water sources provide food - watercress, tuna/ eel, just as the forests provide deer, possums, pigs and for previous generations medicines or rongoa. Davis (2000) describes mahinga kai as more than just a process of food gathering, as it provides Māori simultaneously with spiritual nourishment as well as nourishment of the heart. It is thus impossible to separate what takes place on the farm from the surrounding environment.

6.4.2 Formal monitoring and agricultural technology

Formal monitoring is suggested as providing farmers with a “stewardship accounting tool” in the face of greater pressure from government resource agencies, farmer organisations, environmentalists and consumers alike to manage land in a sustainable manner (Kelly and Bywater 2005, Morriss *et al.* 1998, Bennett *et al.* 1999). Systematic, rigorous and therefore transparent monitoring methods could be used in order to strengthen the farmers’ position while simultaneously encouraging self-regulation (Wilkinson 1996, Morriss *et al.* 1998: 48). As formal monitoring is often dependent on specialised equipment and skills, it is useful to examine some of the key factors influencing the historically low uptake by farmers of researcher-developed technologies. Initially, it was suggested that farmers were merely reluctant or lazy when it came to picking up new technologies (see Taylor *et al.* 1992) however a review of the literature reveals a more complex range of reasons. These can be summarised as follows:

Table 5. The low adoption of agricultural technology

CATEGORY	DESCRIPTION
Imposition	Pretty (1995) argues that while a technology may benefit the environment through conserving a resource, a low rate of adoption typically results if the technology is imposed on farmers.
Lack of relevance	Measurements perceived by farmers as theoretical and not practical with production agriculture viewed as separate from conservation agriculture (Wiley *et al.* 1993, cited in King *et al.* 2000). A further complicating factor is that scientists experience quite different conditions from those experienced by farmers, with few farmers able to adopt entire packages of technologies without first making substantial adjustments (Pretty 1995).
Personality type	In order to link an individual with their likelihood of adopting a new technology, categories of "personality types" have been developed which use simple demographic information such as education, income, farm size and social status (Rogers 1983). The farmers are then boxed into one of 5 categories ranging from "innovators" to "laggards". Röling (1994) highlights richer farmers as being "…the usual option" for technology transfer.
Time and money	Cost and time factors combined with the need for specialised knowledge and equipment impede the uptake of "the most comprehensive" science-based indices (Sojka and Upchurch 1999, Ditzler and Tugel 2002).

Bradshaw and Williams (1998:7) note grants and subsidies function as useful incentives for helping farmers either start or speed up the process of adopting sustainable land management practices.

While some farmers may regard the role of science as providing a technological fix for agricultural issues (Nerbonne and Lentz 2003), there are numerous examples which highlight a rather more complex relationship between formal and informal methods, and by default, agricultural technology and non-technological methods. Many studies clearly demonstrate that farmers integrate a wide range of measures to assess resource condition. In this study, formal methods often served to compliment rather than compete with informal monitoring methods. Both Wilkinson (1996) and McGown (2002) state that farmers are unlikely to replace their informal methods with formal methods if this means placing their hard earned knowledge gained through experience to one side. McGown (2002) for example found that even when farmers did adopt computerised decision support systems they strived to make minimal use of the system. Furthermore, the reliance on using these systems decreases, in tandem with increases in the farmers' own learning. Bennett *et al.* (1999) found that formal assessments were more specifically directed towards optimal fertilizing for crops and soil fertility monitoring whereas informal methods were used to underpin broader management decisions, on a daily and seasonal basis, as well as for capital investments. This suggests that these different methods of assessment may be complementary rather than substitutes.

6.4.3 Industry bias

A further barrier to some farmers when considering laboratory-based methods of soil testing centres around the issue of biased information, as industry representatives typically carry out these tests. In New Zealand, farmers have expressed the need for independent advice free of commercial interest (Nimmo 2005:5). This situation is by no means unique to NZ, with similar concerns raised in Australia and in the UK over the conflicting advisory and marketing roles of the soil tester (Lobry de Bruyn and Abbey 2003). In the UK for example, farmer concerns about the environmental impacts of increased fungicide, herbicide and insecticide usage combined with the associated economic costs has resulted in more extensive use of independent farm advisors (Lyon 1996).

> *F1 …you've gotta be able to read between the lines and find out what they're really saying and you ask a rep about the other rep's product and he'll tell you how bad it is, so whose telling the truth? So I've always been a bit nervous about that…*

The value placed by farmers on the information provided depends on whether the representatives are perceived as trustworthy, experienced and knowledgeable about local conditions as well as their honesty – whether they are able to acknowledge what they do not know (Bradshaw and Williams 1998: 16). In the current study, participants' thoughts differed with respect to information provided by industry. One farmer had previously farmed in a different region with a markedly different soil type and climate. The decision to use industry advice reflects the farmer's move from being an employee and therefore not responsible for assessing and purchasing inputs, to being both a farm owner and manager. A further incentive to use commercial soil testing was that the service was provided free of charge and available as and when required (though under the proviso that the farmer purchase the fertiliser from the company providing the soil tests). The data provided through soil testing are validated through having achieved a successful outcome:

> *F6 When we first cropped that [paddock] over there, we got a guy out from Ravensdown [explains sampling method]… from the results he worked out how*

much fert we needed, when to put it on and then how much to put on later on [...] they came and took some samples for the grass and they said to sow it with about 250 kg's and 500 kg's of lime, mixed, so we did that and it grew like anything...

Other farmers in this study felt differently, several wary of potentially conflicting advice given by different salespeople marketing the same products. This is linked to a sense of vulnerability given the farmer's own lack of knowledge in certain areas. In several cases, though farmers acknowledged the representatives' level of expertise and used them as sources of information, the farmers also did not weigh industry advice too heavily:

F8 [I] mainly talk to the reps that come around [but]...you gotta be pretty staunch with them! They push their.... try to sell you their "top" products, try to sell products that they think are good.

F7 ...we've had ...[a] couple lectures from those guys, but they're just salesmen selling sprays [and] their seeds so you don't get into it that much...

In order to verify the information provided by industry, one of the farmers interviewed relied on the experience – and honesty - of local people to evaluate new products:

F1 ...whose the likely guy that will've used this stuff? Talk to them [...] normally people are straight up and down, "don't go near that stuff, it's a waste of time" and then you ask them why and it maybe because they've used it in the wrong area or in the wrong way, so you can sort of evaluate, again, it's a matter of you sorting out what's the real stuff and what's the bullshit if you like, but product reps I've found very mmm, no I don't really go there, you're better off to go to users.

The wariness with regard to industry-led advice may be well founded. Bell (2004) describes worst-case scenario farming as is occurring in mid-western U.S.A., where increasing farm production and therefore increasing reliance on e.g. fertiliser, herbicides and pesticides, has locked farmers into a risky high input system extremely dependent on a politics and market forces. In short, what Bell details is the other end of the high input spectrum, where farmers are largely powerless to determine their own destiny let alone that of the environment.

6.5 Conclusion

Examining the range of formal and informal monitoring methods used by farmers to assess the quality of their on-farm resources provides an insight into both conscious and tacit forms of decision-making underpinning daily and seasonal farm management. Overall, these combined methods are highly diverse, which reflects the extensive range of factors linked to the farm as a socio-cultural and economic system situated in a modified natural environment. The choice of formal and/or informal monitoring methods is therefore inextricably linked to a wide range of current and historic factors. Farmers' informal methods of monitoring range widely and are based primarily on factors the farmer can observe and experience directly. As such, these are integrated into daily and seasonal activities and occur as a matter of course. Commercial soil testing was the most common formal method used and is generally more widely used by farmers either wanting to improve pasture / crop productivity or are already engaged in more intensive styles of management. Industry bias – given soil tests are carried out by fertiliser suppliers, however remains an unanswered problem for those that cannot afford independent advice. This study showed that combining formal and informal monitoring methods for farmers as both kaitiaki and producers can provide a means toward regulating inputs and thus ensuring that the land and water maintain their life-supporting functions. A stronger understanding of the motivations underlying soil testing frequency (or whether soil testing is carried out at all) warrants further research given the likelihood of SQ maintenance remaining a largely "voluntary" (i.e. unlegislated) activity in New Zealand, and thus remains the responsibility of the farmer.

7 GENERAL DISCUSSION

7.1 Introduction

Policy-makers, researchers and the farmers themselves recognise that soil quality is an essential component of sustainable agriculture (Herrick 2000), yet it is well known that farmers and scientists describe and measure soil health using different languages (Sikana 1994, Niemeijer 1995, Sillitoe 1998, Grossman 2003, Harris and Bezdicek 1994, Talawar and Rhoades1998, Sojka and Upchurch 1999, Lobrey de Bruyn and Abbey 2003, Pawluk *et al.* 1992, Cools *et al.* 2003, Desbiez *et al.* 2004). Farmers methods differ, just as their tools do. Farmers typically communicate with descriptive properties and use qualitative measures to assess soil health whereas technical experts and emphasize analytical methods to quantify diagnostic soil properties (Harris and Bezdicek 1994). The fundamental differences in the approaches to determining SQ clearly reveal the tension between science and local or traditional knowledge (Sojka and Upchurch 1999, Letey *et al.* 2003, Sojka *et al.* 2003). This tension simultaneously reveals both the *scope* and the *limitations* of scientific knowledge and local knowledge. The primary objective of this chapter is therefore to examine these differences in perception in other words, how each is characterised, promoted as well as how each is used. This is a necessary foundation to build, as without a context it is difficult to understand the barriers that may stand in the way of knowledge integration. The second objective is to question how these knowledges, while seemingly so different, may function not as opposing forces but linked together and drawing from each other. The guiding assumption here is that knowledge integration is critical. The literature clearly shows that the benefits lie not only in creating a broader pool of knowledge from which to design more sustainable agricultural systems, but socially too as farmers are able to take a more proactive role in shaping their future.

The third objective of this chapter is to underscore the importance of the methods used for data collection. In order for effective systems to be developed which capitalise on what differing knowledges can contribute toward developing sustainable agricultural land uses, the methods used by researchers to gather local knowledge must be critically examined (Oudwater and Martin 2003). The inclusion of reflections on the methods used in this study highlights that the function of research is not only to *learn* but also about *learning how to learn*.

7.2 Epistemic divides

How are scientific knowledges and local knowledges viewed by the supporters and opponents? Pretty (1995) argues that the positivist or reductionist approach taken by scientists excludes other methodologies because of its absolutist position. In this respect, conventional science has often disregarded local knowledge, questioned its validity and labelled it as "primitive", "irrational", "parochial", "unscientific" or just "wrong" (Walker 1997, Murdock and Clark 1994, Thompson and Scoones 1994, Tsouvalis *et al.* 2000). Scientific knowledge has reached the almost undisputed status of intellectual authority and is thus used to legitimise actions[24]. The methods employed for example by the Practical Farmers of Iowa (PFI), a group engaged in alternative agricultural practices, rely on scientific trial design. Science is promoted as being an empowering tool enabling farmers to "…quantitatively evaluate" their alternative practices through producing results seen as credible by both specialists and farmers alike (Exner and Thompson u.d.). This implies that claims made by proponents of alternative agriculture may be disregarded without recourse to a "trusted" method of measurement.

Local knowledge by contrast, has been relegated to "…the epistemic peripheries, its utility so poorly recognized that we have difficulty even labelling it" (Kloppenberg 1991). The reliance on science and technology as the tools for sustainable development are the unifying themes in the 1987 Brundtland Report (Murdoch and Clark 1994). Today, the public by and large believes that science has a strong role in areas such as environmental preservation and improving agricultural quality (Hipkins *et al.* 2002:19, 64), despite the abstruse nature of scientific activities to most laypeople (Murdoch and Clark 1994). However in the U.S.A, the general public supports a primarily reductionist approach, thus relying on scientific experimentation to create a technical "fix" for agriculture (Nerbonne and Lentz 2003). This same attitude is echoed by a New Zealand farm consultant, "Farmers want a magic wand… they want something to throw on the soils to make it alright" (R. Dolby, Pers. Comm.)[25]. The belief is that technological progress will increase material gain while simultaneously overriding the vagaries of nature (Norgaard 2004). However, having identified many of the problems experienced by farmers, conventional science has simultaneously failed to find solutions to these same problems (Pretty 1995). Ironically, science may well be responsible for some of the problems in the first place (Murdoch and Clark 1994). In addition, the trajectory of technological progress creates new problems as Norgaard (2004) notes, "as fast as, if not faster than, agricultural scientists can take them on."

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[24] As Murdoch and Clark (1994) point out, environmental organizations not shy of heavily criticizing the shortcomings of science, at the same time use science (albeit with great selectivity) to support their own causes.

[25] Dr. Rex Dolby. AgroScience Consulting Services (Dunedin) Phonecall May 26, 2005; interview June 3, 2006

7.2.1 Scientific colonialism

Just as colonialism is both manipulative and exploitative, so too is "scientific colonialism"[26]. The implications of an hierarchical view are significant: colonialist science neglects the rights and the values of those from whom the data originally came and ranks its own validity and importance above other forms of knowledge (Cram 2002:7). In this scenario, local knowledge is merely an obstacle to development (Agrawal 1995) because the mode of operation is purely "top down". Simultaneously, as local forms of knowledge are discredited, western authority is strengthened (Sillitoe 1998). Science is the pervasive form of knowledge in the modernization of agriculture (Millar and Curtis 1999) and thus much technical knowledge is developed and held within institutes of higher learning. The role therefore of the scientist (as the technical expert), is to educate "naïve" or "ignorant" rural people through disseminating their own superior technologies (Sillitoe 1998, Thompson and Scoones 1994, Okali *et al.* 1994). Used this way, science presents a threat to indigenous peoples because as an agent of colonialism, it continues to serve only the needs identified by its current patrons, such as local and central government (Walker 1997). Other more subtle ways in which science can overlay other forms of knowledge are demonstrated through interviews which are often (though not always intentionally) biased, as scientific categories are used as starting points. Science then has the potential to dominate or unduly influence the exploration and understanding of farmers' knowledge (Martin and Oudwater 2003).

Conventional science is condemned for its reductionist approach to understanding nature, having become what Durie (1996) describes "an exercise in analysis rather than a synthesis…" built up as it were, from a "…myriad of small parts". It comes as no surprise therefore to see that many authors (e.g. Heramoana Simon u.d., Checkland 1981, Neimeijer 1995, Bawden *et al.* 1984) see local knowledge as representing everything that conventional science does not.

[26] Cram (2002) summarises scientific colonialism as 1. Exporting raw data from a community for the purpose of "processing" it into manufactured goods (i.e., books, articles, wealth, etc.) 2. The scientist believes s/he has unlimited right of access to any data source and any information belonging to the subject population 3. The centre of knowledge and information about a people or community located outside of the community or the people themselves.

Table 6. Characteristics of conventional science and local knowledge

CONVENTIONAL SCIENCE	LOCAL KNOWLEDGE
- Quantitative, objective and positivist	- Qualitative, subjective and experiential
- Truthful, rational, dependable	- Mythical, irrational
- Focused on mechanisms and predictability	- Rich in contextual information
- Precise, time consuming, expensive	- Relatively inexpensive and quick
- If done in optimal conditions, so controlled as to be disassociated from the complexities of reality	- Highly confounded with complexities of the real world
- Universally applicable	- Locally applicable
- Linear	- Cyclical
- Eurocentric, narrow physical scope	- Ethnocentric, spiritual/ cultural focused
- Focused on single/ present generation	- Focussed on future generations
- Materialist and individualist	- Reciprocal and multi-dimensional
- Economic growth focus	- Socio-cultural focus
- Mechanical/ segmented/ reductionist	- Holistic, collective
- Etic	- Emic

Given the characteristics in the above table, local people would appear to live in blissful harmony with nature. Yet there are countless examples amongst indigenous farmers worldwide of unsustainable practices where land use is not connected to its capability (e.g. Ryder 2003, Ericksen and Ardon 2003, Grey and Morant 2003). While superficially this observation may support the case for using scientific knowledge as the framework for resource management, the long term success of any approach still hinges on the vast range of social, economic and political drivers which shape not only the way in which land is used, but also why people are farming there in the first place. As Ryder (2003) points out, many farmers in the developing world are non-indigenous to their localities and do not have the benefit of rich cultural traditions to draw on. Furthermore, even if knowledge were present in these communities, it may not always result in action due to social, cultural, material and physical constraints (Nerbonne and Lentz 2003).

7.3 The sense of place vs. the sense of space

While characterising knowledges results in very broad generalisations, some of the real differences between knowledges become more concrete when viewed, literally at ground level. The importance of farmers' local or place-based knowledge is a dominant theme in contemporary agricultural discourse and is often used as a key point of contrast to the way in which science operates in relation to other forms of knowledge (e.g. Kloppenberg 1991, Roling 1994, Pawluk *et al.* 1992, Cools *et al.* 2003, Desbiez *et al.* 2004). Both the spatial and temporal relationships between farmer and land, and scientist and land differ markedly resulting from the different frames of reference used by each when thinking about agriculture (Thompson and Scoones 1994). Place-based knowledge is derived from decades (and in some cases multiple generations) of observation of the effects of management responses on the land. Extended time periods typically include catastrophic climatic events and so provide valuable information to the farmers on, for example the resilience of their agricultural soils in extreme situations. Scientific experiments (apart from a few notable exceptions) are usually limited in length and therefore may not include valuable data resulting from these larger scale perturbations to the agro-ecosystem.

But there are other facets of these differing temporal relationships to explore. Farmers' activities can only occur "in time" as they continuously adapt to their fluctuating local physical and social environments. This is a passive adaptive approach (*sensu* Walters and Hollings 1990), a classic feedback loop of farmer acts, ecosystem responds (Nerbonne and Lentz 2003). Scientists' thinking by contrast can occur "out of time" as they are able to run experiments within controlled environments (Thompson and Scoones 1994). This can have significant implications both negative as well as positive. An example of the former is when technologies are developed in quite different contexts from those to which they are eventually applied. An example of the latter, is undertaking controlled experiments in which variables are isolated and controlled, thus enabling causal mechanisms to be investigated with a greater degree of precision.

Spatial scale is an important consideration when understanding the physical and conceptual boundaries of knowledges. As was detailed in Chapter 5 (Understanding their soil: farmer learning, farmer knowledge), there is widespread acknowledgement that farmers in managing a whole production system by nature think holistically, yet farmers' holistic thinking may not necessarily extend to viewing the farm and associated environmental impacts within the context of the catchment. Farmer knowledge of their soils is generally focussed on areas that they are most familiar with (Oudwater and Martin 2003, Cools *et al.* 2003). Farmers may therefore have a limited of understanding of the broader scale impact of the movement of nutrients and sediment around the watershed as Ericksen and Ardon (2003) found in their study of Honduran farmers. Scientists in being able to function at larger spatial scales may be able to understand some of the cumulative impacts in a way that is physically very removed from that of a farmer focussed on a single property. This ability to carry out large-scale experiments which include a number of properties within a catchment or even a number of catchments (though potentially increasing the level of risk associated with failure), dramatically widens the opportunity for learning (Walters and Hollings 1990).

7.4 Building bridges

While the above examples highlight some of the inherent differences between epistemologies, viewing local knowledge / scientific knowledge as dichotomous assumes that western science is context and value free, as well as objective - features which lie in direct opposition to locally derived forms of knowledge. As such, the way in which differing disciplines summarise the features which constitute scientific and local knowledge, serves to underline stereotypic views so as to strengthen the argument for using one over the other.

Providing prefixes such as “local”, “traditional” and “scientific” does help to distinguish different types of knowledges, though these seemingly simple and inclusive terms also raise a number of interpretive issues. Concepts such as “traditional” may imply that that this form of knowledge is inert and do not interact with the worlds beyond their communities (Oudwater and Martin 2003). Science itself comprises a broad range of academically defined disciplines, or in a more contemporary sense “epistemic communities” linked through shared methods, subject areas, assumptions about the underlying characteristics of the study and so forth (see Norgaard 2004). A further issue associated with terminology is highlighted by Murdoch and Clark (1994), who argue that such a coarse set of characterisations risk knowledges becoming, “…reified, turned into a fixed material “thing”. One is thus perceived as being ‘right’ and the other, ‘wrong’. Terms such as “local” and “scientific” may therefore reinforce hierarchical differences in knowledges, the broader level implications of which are profound.

Raedeke and Rikoon (1997) suggest that defining knowledges as dichotomous lies in way that researchers typically associate scientific research with research establishments and local knowledge with farmers. In doing so, researchers have assumed farmers to be a homogeneous group and scientific knowledge to be produced in a limited range of ways. Millar and Curtis (1999) found that science was absorbed into farmers’ practices and modified to suit their circumstances, underscoring the difficulty of defining what exactly constitutes local knowledge within an industrialised setting. A similar case is presented in New Zealand with Mātauranga, the term used to describe Māori knowledge. In its contemporary form, Mātauranga underscores the dynamic nature of knowledge, as it derives from a range of sources such as western science, school / university learning and education and is fused with local, traditional and historic knowledge (Harmsworth *et al.* 2004).

There are calls for moving away from the “…constant assertion of difference/ distinction…” between epistemologies, and instead “…to reconcile difference/ distinction by aligning difference/ distinction with affinity” (Heramoana Simon u.d.). There are similarities between rural peoples’ knowledge and agricultural science, as both are general and specific, theoretical and practical, value laden and bound by context as well influenced by relations of power (Talawar and Rhoades 1998).

In 1991, Kloppenberg wrote that there was a clear need for farmers and scientists to engage in dialogue to both capture and utilise existing knowledge in order to create new knowledge. Arguably there is less of a need for *new* knowledge than there is of finding better ways of *integrating* different knowledges. Capitalising on the interface between knowledges presents an opportunity for "…expanding the understanding of ourselves and the world around us" (Durie 1996). Integrating knowledges calls for a blurring of the traditional boundaries segregating disciplines, boundaries which have often been at odds with the nature and scope of the systems studied (Sillitoe 1998).

Placing a greater emphasis on local knowledge does not call for a simple reversal from a purely researcher-led "top down" approach to one that is solely farmer-led or "bottom up". Nor is the aim, as Sojka and Upchurch (1999) fear, to *replace* rational objectivity with farmers' subjective values; in other words a type of reverse colonialism of science by local knowledge. Instead there is a need for a framework to be created, i.e. sensitive and supportive organisational structures able to accommodate bottom up initiatives and where knowledge building is both fluid and dynamic[27]. Beyond this structural framework for integrating knowledges is the need for methods which are not only defensible but culturally appropriate.

7.5 Methodology: the need for a critical approach

In this study, the choice of methods has been emphasized, in acknowledgement of their role as the machinery, which shapes the research and outcomes. At the core of this study is the fundamental aspect of communication across cultures; Maori and non-Maori, urban and rural, academic and land manager. Also emphasized, is the need for taking an informed approach to the social research process. While this may seem obvious, the mechanisms of the communication process are still scantily covered even in the context of socially related soil studies, where the majority of researchers present their findings under the dominant paradigm of objective, detached researcher. A few valuable insights are however offered (notably

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[27] See Roling's example: "Contours of an interactive agricultural science" (1996). The model is integrative, focuses on multiple levels of interaction and is designed for the development of more responsive environmental policies. Knowledge and experience are drawn from diverse pools and a range of "interactive and participatory" approaches underpin this process. While not actively stated, the emphasis on participatory processes suggests a stronger place for local knowledge to inform not only other stakeholders in the research process but also potentially influence policy.

Birmingham 1996 and Cram 2002) and to this small body of literature, I add my own experiences by way of informing other researchers undertaking similar work.

As was discussed earlier, epistemological distinctions can be unhelpful on account of underlying assumptions in the terms used. Importantly however, the differences in worldviews and ways that different actors function within it are highlighted though this process. Firstly understanding each other's culture and worldview is critical (Harmsworth 2004, Tolich and Davidson 1999) (see Chapter 2: Transcultural research). Shared understandings form the basis for a much more fruitful exchange of perspectives on reasons for and solutions to issues plaguing the agricultural sector such as land degradation and the pollution of ground and surface waters through nutrient leaching.

Although a wide variety of methods[28] are used by ethnopedologists (whose culture typically differs from those whom they are researching) to gather data, few detailed explanations are offered as to the success or failure of these methods. There is also little explanation of why particular methods were chosen. The primary method used in the current research was one of extended conversations around selected themes, allowing enough space to flesh out individual personalities, values and aspirations in what essentially became a multiple case study approach (the trade-off in this respect was depth versus breadth). Critical reflection in the form of "lessons learned" is a vital component of the researcher's own learning process. Based on the current study, when seeking potentially sensitive information from other cultural groups consider:

- Reciprocity in terms of trust-building and shared outcomes
- Establishing a rapport through honesty
- Respecting the participant through knowing how to ask questions, knowing when to stop asking questions and when to continue.

7.6 Pluralism: Ag + culture

The agro-ecosystem is complex web of interactions driven by biophysical conditions, external market forces and government policy. A valid argument is that such a complex system can only be understood through multiple methodologies. These methodologies should draw on a broad scope of knowledge, as there is no singular all-encompassing perspective for understanding (let alone managing) issues of the complexity and magnitude now faced (Norgaard 1989). There are further reasons supporting pluralism, namely the association with

[28] Examples include semi-structured interviews, observations, informal conversations, questionnaires, participatory mapping, transect walks and sorting exercises.

cultural and physical diversity. Just as diversity is a cornerstone for function and viability in ecosystems, diversity is also critical for the conservation and protection of cultures and environmental resources (WinklerPrins 1999).

Despite the calls for redesigning agriculture to meet sustainability criteria (PCE 2004a), the terminology used to describe the key physical resource upon which the industry is built reveals that there is significant work to be done to meet these goals. While the term “underground economy” (PCE 2004a) describes soil’s literal relationship to the agricultural industry, the term also highlights soil’s position as a commodity. This economic focus places the soil into an abstract but purely functional realm: the soil resource becomes a bank vault, and sustainability is understood and measured almost exclusively in economic terms. Many cultures still name features in the landscape in anthropomorphic terms; soil and crops are governed by the same needs as humans are, experiencing thirst, tiredness or weakness (Sikana 1994). Arguably retaining this connection acknowledges the landscape and its living mantle can, like human beings, “sicken” if mistreated, or be “healthy” if nurtured. When Bell (2004) advocates putting the “culture” back into “agriculture”, the justification is to re-humanise what has become a highly technical, intensively production-oriented system, which is ultimately likely to prove unsustainable. This represents more than just a “triple bottom line” approach, as it includes culture and spirituality and arguably, retaining this very human connection is a vital part of creating sustainable agricultural systems. This is not an argument for halting progress, but rather one for a greater sensibility and intelligence with respect to designing agricultural systems which will meet both current needs as well as those of future generations.

8 GENERAL CONCLUSION

Soil forms the physical and economic foundation of the agricultural industry. By investigating soil quality (SQ), the complex and interdependent nature of social, cultural, economic and environmental components of the agro-ecosystem is revealed. As such, a pluralistic approach toward investigating SQ is necessary given the multifaceted nature of the agriculture sector and the drivers operating within it. The range of scales within the agro-ecosystem - from individual farm to catchment, from regional to national and beyond, requires effective dialog between stakeholders such as policy makers, industry, scientists and the farmers themselves in relation to maintaining and improving SQ. Just as shared understandings based on a common language clearly understood by the different stakeholders are critical, so too is the nature of the methods used for constructing these dialogs.

How to balance productivity and sustainability remains an open question. Neither science nor the local / traditional knowledge attributed to farmers is infallible. Neither alone can provide a full range of answers to the pressing issue of continued agricultural soil degradation yet the actual and potential synergy between farmer knowledge and scientist knowledge remains largely unexplored territory. Although scientists and farmers approach the soil resource from differing epistemologies there are sufficient overlaps for example, in the basic suite of key SQ indicators for tools to have been developed to assist farmers with systematically gauging changes in SQ.

Farmers do not represent a discrete group. Despite the New Zealand agricultural industry being primarily pastoral, farmers are characterised by their heterogeneity with culture playing a strong role in shaping their worldview and ways of operating within it. Researcher must enter their studies with the understanding that they hold strong responsibilities to those whom they are communication with and wanting information from. As Norgaard (1989) states, researchers are obliged to be "…conscious of their own methodologies, as well as the advantages and disadvantages of the methodologies used by others". This is particularly true when research extends across cultures. The focus on communication is part of a shift which acknowledges that farmers themselves as the land managers possess knowledges which can be expanded, merged and applied in other contexts.

9 RECOMMENDATIONS FOR FUTURE RESEARCH

This study highlights the extraordinary range of values, belief and aspirations held by contemporary Māori within the agricultural sector. Almost invariably, a study such as this will raise more questions than it could ever seek to answer, and while each of the themes explored each warrant further investigation, there are also a number of other related themes. Recommendations for future research are as follows:

- What are the barriers and opportunities for Māori farmers to improve soil health and productivity on Maori land?

- In which ways do information needs for Māori farmers differ from that of non-Māori farmers?

- How can traditional knowledge be used to underpin scientific experimentation in order to determine best practice techniques for SQ conservation within pastoral agriculture?

There are also several general questions (i.e. non-culturally specific), which arise from the current research:

- How can information pathways between farmers and industry/researchers be strengthened to facilitate the flow of knowledge from “bottom to top”?

- Do the SQ assessment tools developed for farmers meet their stated goals in terms of measuring SQ and empowering, educating and stimulating the farmer into action?

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APPENDIX ONE

He Whenua Whakatipu Rationale

Available: http://www.argos.org.nz/documents/Archivemarch2005.doc [Accessed March 2006]

He Whenua Whakatipu has been established to assist Ngai Tahu landholders within Te Waipounamu (South Island) to generate sustainable livelihoods from the land and to generate positive environmental and social outcomes. It has become clear that in order to sustain whanau in their papakainga (or homelands) and their status as ahika (keepers of the home fires), it is necessary to increase opportunity and life options. All of the farms are economically marginal, and therefore, development alternatives need to be considered. Alternatives have been initially explored with whanau, by looking at the natural resources present, and at ways of developing them, mostly as high value agricultural products for niche markets. Cottage industry level value-added processing is also being explored. Off-farm income in terms of tourism has also been deemed as important. Permaculture style development, based on subsistence is also being explored in one case-study as a means to sustain whanau in their papakainga.

In order to achieve its goal, The ARGOS research has a strong development focus and will encourage participation from all those involved. A comprehensive environmental, social and economic monitoring approach is provided to ensure that developments stay on track, and that research participants achieve their goals.

Currently there are six case studies involved with He Whenua Whakatipu. It is expected that two more case studies will come on board by July 2005 making an initial cluster of eight. It is hoped that a second cluster will be established in the following year. The development team is nearing the completion of three development plans with whanau participants, and about half way through completing a fourth. Two of the case-studies are now in the implementation phase and the landowners are very excited about putting these plans into action.
It has become clear that in order to sustain whanau in their papakainga (or homelands) and their status as ahika (keepers of the home fires), it is necessary to increase opportunity and life options. All of the farms are economically marginal, and therefore, development alternatives need to be considered. Alternatives have been initially explored with whanau, by looking at the natural resources present, and at ways of developing them, mostly as high value agricultural products for niche markets. Cottage industry level value-added processing is also being explored. It has been determined that developing a local economy will be crucial to whanau maintaining sustainable livelihoods in their papakainga. Off-farm income in terms

of tourism has also been deemed as important. Permaculture style development, based on subsistence is also being explored in one case-study as a means to sustain whanau in their papakainga.

On-going support from the development team will keep the development ‘on track,’ whilst feedback from the monitoring team provides the on-going information, needed to determine whether the economic, social and ecological resilience of the whanau and their whenua (land) is improving. It is expected that over the next five years the action research within He Whenua Whakatipu will provide important information regarding how rural Māori can be facilitated into sustainable livelihoods on their whenua, and further, how this can continue into the future, providing a foundation for the ahika and therefore cultural resilience within papakainga.

APPENDIX TWO

ARGOS and Soil Health Monitoring

Soil quality has been given top priority amongst all the Agriculture Research Group on Sustainability (ARGOS) environmental variables. This is because it is seen as fundamental to the crop and livestock productivity, but also ecological productivity on the farm. It is also the common denominator through all the sectors and farming systems under study in ARGOS.

The ARGOS Approach to SQ monitoring (Moller *et al.* 2005: 72-80)
In ARGOS, soil quality monitoring consists of making a suite of chemical, biological and physical tests in the field and laboratory. Visual and tactile examination of the soil in the field is the prime tool. It is complemented with a combination of standard and innovative laboratory techniques. The choices of indicators, and the techniques used for those indicators, are strongly influenced by:

- The need to cover biological, physical and chemical aspects of soil quality with techniques that can withstand scientific scrutiny;
- The need for continuity, so wherever possible results can be compared to historical information for New Zealand soils
- A desire to encourage growers and consultants to use low-tech but reliable and meaningful soil quality indicators throughout their operations.

The overall ARGOS approach is to concentrate on groups (clusters) of commercial farms that are under the target management systems and are in close proximity to each other.
Given this, and the likely large spatial variability in soil quality, we chose to monitor paddocks that represent the dominant landforms within each cluster using permanent soil monitoring sites (SMS). This scheme is especially good for comparisons between agricultural and management systems (the prime aim), but it is weak for characterising whole farms. The success of long term monitoring relies on consistency and sampling from permanent soil monitoring sites which have been established using guidelines developed for all agricultural systems.

Soil quality indicators

In order to select the most appropriate set of soil quality indicators, we reviewed the extensive literature. We gave priority to techniques that were:

- Appropriate for all the management systems to be studied in ARGOS;
- Precise, reproducible and scientifically defensible;
- Sensitive to management practice;
- Biologically, physically and chemically meaningful in an agricultural context;
- Rapid and affordable, so that good levels of replication could be achieved;
- Readily adoptable for routine use by land managers;
- Already well-used in the literature, so that comparisons could be made readily published results in NZ and overseas.

A range of qualitative and quantitative soil quality indicators were chosen and prioritised. The higher the priority the more essential the index is. Indicators in priorities one to three are being monitored on a regular basis at all sites. Some lower priority indicators may be used only for detailed studies at selected sites and time, to help our interpretation of trends observed in other measurements.

Soil quality at each site will be defined by the initial set of measurements. The effect of subsequent changes in management can be observed as changes in soil quality relative to the initial measurements.

Priority One

The first priority indicators are a suite of meaningful field observations that can be integrated into one or more soil quality scores. Most are qualitative or semi-qualitative visual assessments rather than quantitative, and are undertaken by the ARGOS field officers. To ensure repeatability, the field officers are trained in the same manner and calibrated against each other. Regular standardization of the visual soil assessment by the field officers (as paired observations) will be required to ensure consistency. The qualitative visual observations will be supplemented by simple quantitative measurements. Priority one measurements were conducted at each individual soil monitoring site.

Qualitative soil measurements

Key soil parameters are assessed based on pictorial comparisons. The visual parameters assessed are:

- Area of exposed soil (%)
- Amount of soil covered in live vegetation (%)
- Amount of soil covered in clover (%)
- Pasture cover (kg DM/ha)
- Area of crusted soil (%) and thickness of crust
- Area damaged by vehicles, stock or erosion (%) and approximate depth
- Presence and thickness of surface organic thatch build up
- Soil porosity (1-4 scale)
- Soil discolouration by mottles or gleying (1-4 scale)
- Soil aggregation (1-4 scale)

Quantitative soil measurements

- Soil bulk density (g/cm3). This is a measure of soil compaction and defined as weight per unit volume. As weight is dependent on moisture content, samples are oven-dried at 105oC to remove all moisture, giving dry bulk densities that can be compared between locations (Blake and Hartge, 1988). Soil bulk density was measured at two depths, 0-7.5 cm and 7.5-15 cm.
- Earthworm populations/m3. These give an indication of the biological, chemical and physical fertility of a soil. Earthworms are important for breaking down and incorporating organic matter, making the nutrients available to plants. Through burrowing, earthworms also mix soil and improve soil aeration and drainage. We have reported the earthworm populations on a per soil volume rather than area basis (Fraser *et al.*, 1999).

Priority Two

These are soil chemical analyses for the topsoil and mostly a standard suite of measurements (Blakemore *et al.*, 1987) that we contracted out to commercial soil testing laboratories. Soil samples are collected from the standard sampling depth for pasture (0-7.5 cm). This may not represent the availability of nutrients from the entire root zone but can still provide valuable information about plant available nutrients and chemical conditions in the soil.
Priority two samples are collected at the management unit level

- Soil pH indicates the level of acidity or alkalinity of the soil sample.
- Olsen P (_g/ml) is a measure of the phosphorus readily available to plant.

- Exchangeable cations (Calcium (Ca^{+2}), Magnesium (Mg^{+2}), Potassium (K^+) and Sodium (Na^+)). Calcium, magnesium and potassium are major nutrients for plant growth. These are reported as both MAF quick test units and milli-equivalents per 100g dry soil (me/100g).
- Cation exchange capacity (me/100g) is a measure of the soil's capacity to hold cations and is strongly influenced by clay content and soil organic matter
- Phosphate retention (%) indicates how strongly the soil will immobilize added phosphate. It is a function of the soils parent material and the level of clay mineral or iron oxides present that immobilise phosphorus.
- Potentially mineralisable N (kg N/ha) is an indication of the nitrogen that may become available to plants through mineralisation of organic matter
- Volume weight (g/ml) is the weight per volume of the air dried and ground soil used by the laboratory for chemical analysis. It is sometimes referred to as "lab. bulk density" and should not be confused with field bulk density as measured in priority one.
- Total organic C and N %. Organic matter is important as it supplies nutrients to the soil, improves soil physical fertility and moisture retention (Sheldrick 1986). Soil carbon is directly proportional to the soil organic matter (%C x 1.72 = %SOM).

Priority Three

Priority three indicators use the same sampling depth and soil samples as used for priority two measurements, and relate to the biological activity of the soil. The indicators are described below.

Microbial biomass carbon

This is a measure of the total amount of living microbes in a soil (Vance *et al.*, 1987). Microbial biomass usually constitutes around 1-4% of total soil organic matter. In temperate climates there is often a fast rate of microbial turnover that suggests that microbial biomass is a more sensitive indicator of changes in total soil organic matter than total soil carbon. Microbial biomass levels will differ between soil types and land use history.

Basal respiration

Soil micro-organisms recycle essential nutrients when they decompose dead plant and animal material. Hence an active microbial population is a key component of good soil quality. Measured in the laboratory, microbial respiration is a process that reflects the potential activity of the soil microbial population. Microbial respiration is the amount of carbon dioxide production over a fixed period (Anderson, 1982).

Metabolic Quotient

The ratio between microbial biomass carbon (the size of the soil microbial population) and basal respiration (the activity of the soil microbial population) is a useful indicator of the metabolic efficiency of the microbial population.

We intend to repeat routine monitoring regularly for at least five and maybe up to 20 years. Time trends that may appear in the results will help us to make the more detailed and robust comparisons mentioned above. Also, in some years it may be possible to carry out some more intensive measures on specific farms to test sharp hypotheses about the effects of the management systems and differences between individual farms.

APPENDIX THREE

Timeline summarising agriculture and legislation impacting on Māori

OVERVIEW OF FARMING IN NZ	YEAR	LEGISLATION AFFECTING LAND USE AND OWNERSHIP BY MĀORI
Early farming: - Kumara gardening - Arrival of settlers; hunting and harvesting of birds and seafood - Samuel Marsden introduces cows to his mission (1815). Dairying widespread within 30 years in both the North and South Islands	**Pre-1840**	
Extensive pastoralism: - Grazing on East Coast, North Island grasslands and tussock grasslands of the South Island - Natural limits of production reached by 1870's	**1840 – 1870**	**1848 - Treaty of Waitangi:** guarantee of full, exclusive and undisturbed possession of Lands and Estates, Forests and Fisheries; guarantee of tino rangatiratanga, rights and privileges of British subjects and recognition of taonga
		1862 - Native Land Act
		1863 - Suppression of Rebellion Act: allowed the confiscation of Māori lands as punishment of "rebel" Māori
		1865 - Native Land Act: to determine and record titles of Māori customary land; laid foundation for the Native Land Court to be established. Emphasis on individualisation of title – Certificate of title could be issued to no more than 10 owners ("10 owner rule")
		1867 - Native Land Act: required names of all other owners in addition to the 10 owners on the title registered and endorsed on the Certificate of Title
Expansionism: - Evolution of permanent grassland system through extensive burning and clearing of forests - Wheat boom in 1870's contributes to soil depletion - Refrigeration (1882) and expansion of railway systems enable meat, butter and cheese exports - Dramatic increase in value of wool and grain (1890-1910)	**1870 – 1920** Maori population plummets; common conception: the end of Māori culture	**1873 - Native Land Act:** Memorial of Title to replace the Certificate of Title. The Act allowed the Native Land Court to fragment land ownership among Māori. Individual Māori received shares in blocks subsequently divided and re-divided into uneconomic units. This costly process combined with the ordinary costs of living pressured many Māori into selling their interests. While the original intention of the Act was to slow land selling, Crown and private purchasers alike employed secretive methods to secure ownership of Māori land. The resulting fragmentation has bedevilled Māori land ownership ever since, creating significant barriers in borrowing development capital or in utilising much Māori freehold land productively.

Early Intensification: - Marginal lands developed post WW1 with varying success - Development of soil science and fertiliser; introduction of improved grass species	**1920 – 1950** Māori start to move off land (1930's) 25.7% Māori urban dwelling (1945)	**1929 - Māori land development schemes set up.** Native Minister Sir Apirana Ngata developed the Māori Incorporation, an organisational structure introduced by to overcome limitations of multiple title. Incorporation of land into single legal entity controlled by a "committee of management" – similar structure to joint stockholder company. Large accumulating debts of some schemes resulted from inadequate Crown management, the costs of which had to be borne solely by iwi.
Diversification: - "Grasslands revolution" resulting in doubling of farm output between 1945 and 1970 - New mechanical and electrical technologies introduced along with improvements in soil fertility, animal breeding, pest control etc - expansion in horticulture, deer and goat farming (1970's) - broader global market and significant increase in govt. support in response to falling agricultural prices (mid 1970's)	**1950 – 1980** Significant increase in urban migration, "A trickle that would become a torrent in the 1950's and 1960's" (King, 2003: 416)	**1953 - Māori Affairs Act:** emphasis shifted toward retention of Māori land. Provisions to simplify land titles and facilitate use of Māori land found to be "uneconomic" with court given power to vest uneconomic interests in Māori Trustee. – Māori trustee could purchase interests from the owners without their consent **1967 - Māori Affairs Amendment Act:** compulsory conversion of 'Māori freehold' land with four or fewer owners into 'general land', and increased the powers of the Māori Trustee to compulsorily acquire and sell 'uneconomic interests' in Māori land. The Act lead to strong protests due to concerns that the law would result in further alienation remaining Māori land. 1974 – Modification and drafting of a completely new Act.
Intensification: - Deregulation of farming sector (1985) and removal of subsidies. Reforms encourage increasing productivity - Further diversification: kiwifruit, forestry, viticulture, organics - Substantial expansion in dairy industry in response to global market demand	**1980 – present** Considerable movement of Māori back to rural areas (1991 – 1996), though over 81% Māori dwelling in urban areas (1996)	**1991 - Resource Management Act:** provides a strong basis for tangata whenua participation in policy development and management for the natural environment. Requires values and concerns of tangata whenua to be accommodated. There are however a number of issues: - Lack of national policy frameworks or standards to ensure efficient, consistent and reliable systems for tangata whenua participation in environmental management; - Lack of appropriate accommodation of tangata whenua values and concerns; - Often poor consultation / communication between local authorities and tangata whenua; - Complexity, awkwardness and inefficiency of current processes; - Limited resourcing available for involving tangata whenua in environmental management **1993 - Ture Whenua Māori Act / Māori Land Act:** emphasis on retention of Māori land and promotion of occupation, development and use for the benefit of owners and descendants. **2003 – Local Government Act**: further devolution of power; further issues with consultation between local government and iwi / hapu.

(sources: PCE 1998, King 2003: 416,473, Kingi 2002, PCE 2005: 32-33, www.treatyofwaitangi.govt.nz)

APPENDIX FOUR

2005 Demographic for study participants

Farmers	ownership/position	% income from farming	# of years farming	# years on current farm	Paddock area	Management
F1 F2	Māori Land Trust	10% 10%	25+ 20	59 28	620 acres	Dairy cow fattening, c 200
F3	Māori Land Trust	100%	30	17	190 hectares	150 cows; will change to sheep in 2006
F4	Owner/ Operator (Family land)	20%	40	49	100 hectares	Sheep & beef
F5	Owner/ Operator (Family land)	66%	38	36	200 hectares	Sheep & beef
F6	Owner/ Operator	100%	30	4	230 acres	Sheep & beef
F7	Farm manager for 3 farms plus owns and operates own farm	100%	40	4	Managed: 1500 hectares Own: 140 acres	Managed: Dairy Own: converting from sheep to beef
F8	Farm employee	100%	15	5	188 hectares	179 cows, 8 beef

APPENDIX FIVE

Interview analysis codes

The following codes were used to define key interview themes as well as emerging sub-themes.

IND	INDICATOR
I-ph	Physical
I-b	Biological
I-ch	Chemical
I-cr	Crop
I-st	Stock
Man	Management of soil quality
KN	KNOWLEDGE
K-loc	Local knowledge
K-exm	Experiment; learning through experimentation
K-exp	Experiential knowledge
K-int	Intuitive knowledge
IF	INFORMATION SOURCE
IF-ln	Information from local network
IF-f	Formal education
IF-r	Reading material
IF-d	Discussion groups, farm advisors, industry reps, field days
IF-I	Internet
IF-rc	Regional council
MON	MONITORING
M-f	Formal method
M-inf	Informal method
M-st	Soil test

APPENDIX SIX

Interview questions

Below is a sample of the questions used during farmer interviews. Questions were asked in different ways and in different orders dependent on the nature of the interview and interviewee.

SOIL QUALITY and MANAGEMENT

- How do you describe a healthy soil?
- What are the main things you use which tell you about the condition of your soils?
- What type of inputs do you use?
- How do you decide what kind of inputs to use and what quantities to apply?
- On your farm, what factors do you feel have the greatest impact on soil quality?

KNOWLEDGE and SOURCES of INFORMATION

- How long have you been on your farm for?
- Where do you get most of your information relating to farm management from? (Prompt: passed down through family? From local farmers?)
- What are some of the main things you learnt through your parents/ grandparents in relation to the land? How does that knowledge affect the way you manage your land?
- What forms of media do you access in relation to farm management? (Prompt: Newspaper, TV, Internet, A&P shows/ Field days?)
- Which source do you consider provides you with the best information? Why?
- Are local information networks strong? Does this provide you with reliable information?

MONITORING/ TESTING

- What types of monitoring/ testing do you do?/ do you want to do?
- What made you decide to use these particular methods?/ Why would you use these particular methods?
- What information do you get from the tests /would you want from a test?
- Does/ would somebody else interpret the results for you?
- Do/ would the results provide you with a better understanding of the way your soil functions? Is this what you would want out a soil monitoring programme?
- What sort of time frame do/ would you allow for soil monitoring/ testing?