Sustainable water management:

An approach based on the Gaia hypothesis and the traditional Maori worldview

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Abstract

This thesis seeks to develop an approach to water resource management that is compatible with the concept of sustainability. Water resource management implies management of the whole ecosystem, including people. The current approach to management tends to be based on western scientific rationality. This 'rationalistic' approach is found to be incompatible with the sustainability concept, at both conceptual and practical levels. New approaches to management are required.

Western (reductionist) science represents a particular view of the world. Other views are possible and may be more relevant to the sustainability concept. The Gaia hypothesis, for which there is now widespread scientific acceptance, and the traditional Maori worldview are chosen to provide a new approach to understanding how nature functions and a new approach to management.

The Gaia hypothesis implies that ecosystems, integral parts of The Biosphere, can be viewed as 'open-systems'. The concepts developed in non-linear thermodynamics to explain how open-systems function are used to provide insight into how ecosystems function. These insights lead to the belief that nature is an unfolding, learning, creative process.

Communities must 'learn' as ecosystems 'learn'. A Gaia-based approach to management involves community at a 'grass-roots' level in the decision-making process. Approaches to community-based management currently being developed in the Great Lakes are used as a model for management in New Zealand.

The traditional Maori approach to management evolved from a need to develop sustainable management practices, because earlier Maori management approaches had resulted in resource depletion. The Maori approach is investigated for its sustainability, and is found to have resulted in sustainability at both a practical and conceptual level.

The Gaia-based and traditional Maori approach are similar at the conceptual level, but their practical application varies as a consequence of different cultural and historical factors. Obstacles to implementing a joint Maori and Gaia-based approach arise, but are mainly a consequence of attempting to initiate 'new' style of management. Researchers in many parts of the world are discovering methods for overcoming the obstacles that are raised.

The joint or 'unified' approach is used to develop sustainable management strategies for Lake Forsyth in Canterbury. The approach is found to provide a way of simultaneously considering many issues in the same framework and the approach has many advantages over the current management approach. However, it is not possible to say whether the approach will definitely work in the Lake Forsyth ecosystem; this can only be determined in reality, by trying it.

Keywords: Gaia, Maori, cosmology, mythology, bifurcation, sustainable management, Lake Forsyth, Wairewa.

Foreword / Mihi

This is a thesis about the mythology upon which science is based. All scientific frameworks, such as Newtonian (reductionist) science, quantum physics, Maori science, are founded on myths of the way nature functions. Myths are part of culture. Science reflects a culture's values, and science is seen in this thesis as a culturally-based, or 'value' system. Different sciences present different pictures of the world, just like different artistic painting techniques, such as impressionism.

The current western approach to management is based on the myth that nature has machine-like properties. This myth is not conducive to sustainability. This thesis aims to develop a myth about nature that is compatible with sustainable management and suits both western and Maori cultures. The development of a new myth is accompanied by the development of new concepts and a new language for describing nature and human uses of ecosystems.

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"Sustainability ... cannot be divorced from culture and community." (Jackson, 1991, p30)

"Study of ecosystems should not neglect the human milieu as disruption of nature stems from socio-economic processes." (George Pict, quoted in Serafin and Zaleski (1988), p 99)

"The traditional scientific method [reductionism] *is quite pointedly anti-spiritual, with its practitioners preferring to confine themselves to the 'facts'. But while this approach has undoubtedly brought us many benefits, it's becoming clear that it's also very limited."* (Bachman, 1989, p49).

1.1 Thesis introduction

The need to give effect to the term 'sustainable management', introduced into law through the Resource Management Act (1991), requires a radical alteration in environmental management. Humans are not using the environment, either in New Zealand or globally, in a way that can be sustained (Glasby, 1991; World Commission on Environment and Development, 1987). Given that systems for managing human uses of the environment should be based on an understanding of the way ecosystems function, more reliable models of ecosystems are needed in addition to better of ways of designing management systems.

The objective of this thesis is to develop an approach to managing water resources sustainably, and, by implication, other resources. An 'approach' is a way of going about tackling a problem (Checkland, 1981a). A 'water resource' is part of an ecosystem associated with fresh water that humans could directly use, such as a fishery or a river. 'Managing' refers to the process of controlling human **uses** of ecosystems; humans do not manage ecosystems, only their uses and abuses of ecosystems (Vallentine and Hamilton, 1987). 'Sustainable' describes management which does not compromise the needs of future generations (further defined in chapter 2).

There is increasing recognition among resource managers that sustainable management requires integrating 'social' and 'technical' considerations. Therefore, this thesis is concerned with the process of taking research and turning it into strategies which society can follow, a process which Timberlake (1989) considers to be a key aspect of implementing 'sustainable management'.

This approach to sustainable water resource management is developed with New Zealand's water resource problems in mind. Given the emphasis of the Treaty of Waitangi on public policy and resource management matters, the approach needs to meet both Maori and European cultural values and expectations.

An approach to sustainable water management must cope with the range of human activities which have an impact on fresh-water resources, such as land use, water abstractions, and flood mitigation. Therefore, much of this thesis is concerned with the broad topic of resource management, rather than solely the management of water.

1.2 Context: moving from reductionist to ecosystem approaches

Western society has traditionally used reductionist scientific approaches to resource management (discussed in chapter two). Reductionist approaches use numerical techniques, technical experts' perceptions of 'the problem', view humans as being separate from the environment, and separate social, economic and ecological relationships. Management approaches based on reductionism tend to be inflexible and have difficulty coping with the complexity of ecosystems (Holling 1978; Likens 1989).

While reductionist approaches have proved useful in some management situations, the large number of unforseen environmental and social problems currently being experienced both in New Zealand and around the world would suggest that reductionist approaches have not provided resource managers with sufficient understanding of how ecosystems function. New approaches to management are needed.

Policy researchers around the world are discovering that 'ecosystem approaches' to management are of most use for developing and implementing strategies which have sustainable outcomes (e.g. see Regier et al, 1989; Vallentine, 1988; Hartig and Hartig, 1990). The concept underlying the ecosystem approach is that people are an integral part of an ecosystem. Thus, ecosystem approaches seek to consider social, economic and ecological relationships in the same framework.

This thesis seeks to replace the unsatisfactory reductionist approach to management (outlined in chapter 2) with an approach that is compatible with the concept of an 'ecosystem approach'.

1.3 Thesis structure

Following this introductory chapter, seven chapters are arranged into three parts (Figure 1.1).

Part One comprises two chapters on sustainability and management approaches. In chapter two sustainable management is defined. The characteristics of a sustainable society are discussed and a set of criteria for sustainability is developed against which management approaches can be assessed. The current reductionist approach to management is assessed for its compatibility with the concept of sustainable management.

In chapter three the foundations of a management approach are discussed in an analysis of paradigms. This leads to the alternative approaches to management which are developed in part two.

Part two comprises three chapters on developing an approach to sustainable management. Firstly, the Gaia hypothesis is used to develop an approach (Chapter four). Secondly, the traditional Maori approach to management is outlined and assessed for its contribution to sustainable management (chapter five). Chapter six compares and contrasts these two approaches and develops a 'unified' approach. Obstacles to implementing the approach and methods to overcome these are discussed.

Part Three comprises two chapters on the application and an assessment of the unified approach. In chapter seven the approach is applied to water management in the Lake Forsyth Catchment. An appraisal of the approach is made in chapter eight. Directions for future research into sustainability are recommended, followed by the conclusion.

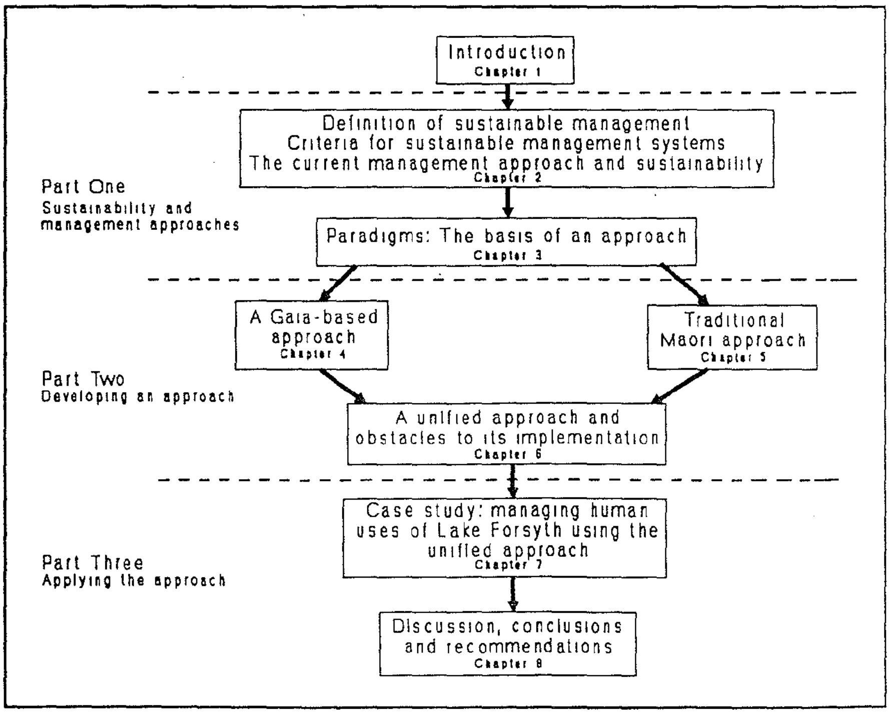

Figure 1.1: Thesis structure

Part One

Sustainability and management approaches

Chapter 2 Sustainable management and the current management approach

"I have described the earth, and all the visible world, as if it were a machine." (Descartes, 1644; Quoted in Abram, 1988, p119)

"The basic causes of our environmental troubles are complex and deeply embedded. They include ... our failure to perceive the environment as a totality and to recognise the fundamental interdependence of all its parts, including man himself..." (President Richard Nixon in a report to the Environmental Quality Council, 1970. Quoted in Oates, 1989, p14).

"Because nature is so heterogeneous, reductionist approaches often are of limited usefulness in unravelling the overall complexity of natural ecosystems." (Likens, 1989, p178)

"... those who use quantitative information in the policy process are discovering that something is wrong. Numerical information is capable of seriously misleading those who use it." (Funtowicz and Ravetz, 1990, p10)

2.1 Introduction and chapter structure

In this chapter sustainable management is defined. The characteristics of a sustainable society are discussed and criteria are established for 'sustainable' management approaches. The current reductionist approach to managing water resources is compared with the criteria.

2.2 Sustainable management: Definition

The concept of sustainable management, introduced in the Resource Management Act (1991), means in New Zealand law;

> *'managing the use, development, and protection of natural and physical resources in a way, or at a rate which enables people and communities to provide for their social, economic, and cultural wellbeing and for their health and safety while -*
>
> *(a) sustaining the potential of natural and physical resources (excluding minerals) to meet the reasonably foreseeable needs of future generations; and*
>
> *(b) safeguarding the life-supporting capacity of air, water, soil, and ecosystems; and*
>
> *(c) Avoiding, remedying or mitigating any adverse effects of activities on the environment.'*

The key component of the sustainable management concept is biophysical or ecological sustainability. This biophysical/ecological element is viewed in both the Resource Management Act and this thesis as the **basis** which sustains economic and social wellbeing. Human society is thus inextricably linked with The Biosphere[1], and is dependent upon The Biosphere for its wellbeing.

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[1] Following the editorial practice of the International Society for Environmental Education (as outlined in Vallentine and Hamilton, 1987) and the journal *Environmental Conservation* The Biosphere and Earth are capitalized as place names.

2.3 Characteristics of a 'sustainable' society

The characteristics of a society which sustainably manages its uses of ecosystems (a 'sustainable' society) have been discussed in numerous publications. This section outlines the points of agreement and briefly assesses western society's sustainability.

A sustainable society will formulate its actions using the principle that humans are an integral part of an ecosystem[2] and are dependent upon ecosystems (i.e. The Biosphere) for their wellbeing. Thus, a sustainable community will ensure that the life supporting capacity of their ecosystem is sustained.

Sustainable communities will need to be aware of how their ecosystem functions. The physical characteristics of ecosystems, such as climate, soils and social conditions, vary spatially and temporally. It is often 'local people' who have a specialized knowledge of an area. Thus experts, who have generalized knowledge (Berry, 1990), will help local people to 'understand the genius of place[3]' (Jackson, 1991) and help communities to make decisions that are based on an understanding of the local conditions. A characteristic of sustainable management, therefore, is an informed community participating in decision-making.

A sustainable society will not produce waste at a greater rate than an ecosystem can assimilate it. Thus, a sustainable society will be a conserver society (McChesney, 1991).

Anticipatory and preventative actions are a requirement of sustainable management. Unexpected outcomes, which can damage ecosystems, take time to detect with the result that damage to an ecosystem tends to be underestimated (Scimemi, 1987). Solutions aimed at dealing with problems therefore tend to be under designed and environmental damage continues to occur, reducing future generations' wellbeing. A sustainable society will make cautious decisions and anticipate problems rather than always having to be in a position of reacting to them after they have occurred.

[2] An ecosystem is defined by Vallentine and Beeton (1988, P58) to be:
'A subdivision of The Biosphere with boundaries which are arbitrarily defined according to some particular purposes in hand.'

[3] 'genius loci' in Latin. The brilliance of place, the features which give a place its feel, its spirit.

Diverse economic activity will characterise a sustainable society. Diversity increases resilience and increases the likelihood of long-term stability (Munn, 1989). Thus, a sustainable community, be it a region or a nation, will attempt to spread its economic activity over a range of options and avoid 'putting its eggs in one basket', as for example in agri-monocultures.

At present society does not organise itself around the constraints of The Biosphere and uses The Biosphere in an unsustainable fashion (World Commission on Environment and Development, 1987). For instance, society produces waste far in excess of nature's ability to assimilate it (Glasby, 1988). A fundamental change of direction in economic, social and environmental policies is needed (Auckland Regional Council, 1990), and society has to make far more than small concessions to the environment (McChesney, 1991). Thus, the adoption of the concept of sustainable management will require a major change in the way society uses The Biosphere.

2.4 Criteria for approaches to sustainable management

To change the way humans use The Biosphere new approaches to management may be needed, rather than merely tinkering with existing management approaches (Regier at al, 1989). This suggestion is investigated in the remainder of this chapter. Firstly, criteria are established for a management approach that is likely to produce sustainable outcomes.

A 'sustainable' approach to resource management must operate on the principle that human society is part of an ecosystem and depends on The Biosphere for its wellbeing (see section 2.1). The following criteria are compatible with this principle. They are derived from the previous section on the characteristics of a sustainable society, from Vallentine and Hamilton (1987) and from the International Union for Conservation of Nature and Natural Resources (1981). The criteria overlap to some degree.

The criteria for a sustainable management system are as follows:

- **Integration of Knowledge:** Management systems must be capable of integrating social and ecological information, both of which have qualitative and quantitative components.

Integration of knowledge refers to both the acquisition of knowledge through research and the dissemination of knowledge through the educational process, such as 'extension'.

- **Holistic Perspective:** Account must be taken of interactions between different levels of ecosystems such as national, regional and local, interactions within an ecosystem, and interactions between neighbouring ecosystems.

- **Ecological Actions:** Humans exist within The Biosphere. Therefore society must take ecological functions into account. Physical connectivity both within an ecosystem and between ecosystems must be recognised. This leads to concepts of recycling and conserving.

- **Anticipatory and Preventative Actions:** Reacting to ecosystem damage tends to reduce the options available to future generations. Because phenomena tend to recur in nature, damaging outcomes can often be foreseen and prevented or anticipated. Prevention is better than cure and in some instances, such as species extinction, there may not be a cure. Aeeount must be taken of safety factors and lead times.

- **Ethical Actions (respect for other life forms):** The Biosphere sustains human society. When the outcomes of decisions impinge on other living organisms, either directly or indirectly, decisions are taken on the basis of respect for nature, and a belief in the inherent good of other forms of life and their habitats. This criterion basically encompasses the land ethic of Leopold (1966).

2.5 The problem and current approach to water resource management

This section firstly outlines the current management approach, which is then assessed for its sustainability in both conceptual and practical terms. At the conceptual level the current management approach is compared with the criteria developed in the preceding section. At the practical level the outcomes of management strategies are assessed.

2.5.1 The current approach: reductionism

It is difficult to characterise precisely the existing approach to managing water resources. Different methods are in use. For example, the consultative and broadly-focused approach used to set flows on the Waitaki River system (Waitaki Catchment Commission, 1982) is very different to the adversarial and narrow-focused approach used to set a minimum flow in the Wanganui River (Department of Conservation, 1988). Although decision-making processes vary, a generalization can be made: Decision-makers rely upon scientific rationality to manage human uses of ecosystems (Heerdegen and Rozier, 1990).

The reliance upon scientific rationality in decision-making is clearly observed in catchment management plans and in tribunal hearings. In the formulation of management plans scientifically trained people 'define the problem' and the problem becomes structured in a scientific way as a result[4]. In tribunal hearings great importance is attached to scientific evidence[5].

In general, science uses reductionist methods of analysis (Prigogine and Stengers, 1984). Reductionist approaches are based on the belief that nature can be viewed as a machine[6]. Reductionism thus seeks to understand how ecosystems function in the same way a complex piece of machinery is understood; by reducing the machinery to its constituent parts, and objectively observing and measuring the parts.

In a reductionist approach ecosystems are normally reduced 'boxes and arrows' (Figure 2.1; Allen, 1986). Information about the parts (boxes) and relationships (arrows) is collected in numerical terms. The relationships between the parts are described in mathematical form, usually linear, by researchers who are skilled at observing certain phenomena. As a consequence of the high degree of specialization required to view The Biosphere in this way, science develops into very narrow disciplines (Chorley and Bennet, 1978; Pomeroy et al, 1988; Keddy, 1991; Allen, 1986).

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[4] See **any** catchment management plan in New Zealand.

[5] See, for example, the large 'weight' of scientific evidence (which stacks meters high) presented by both the Department of Conservation and Electricorp to The Planning Tribunal in the Wanganui River Minimum Flows Hearing (1989-90).

[6] See quote from Descartes at the beginning of this chapter.

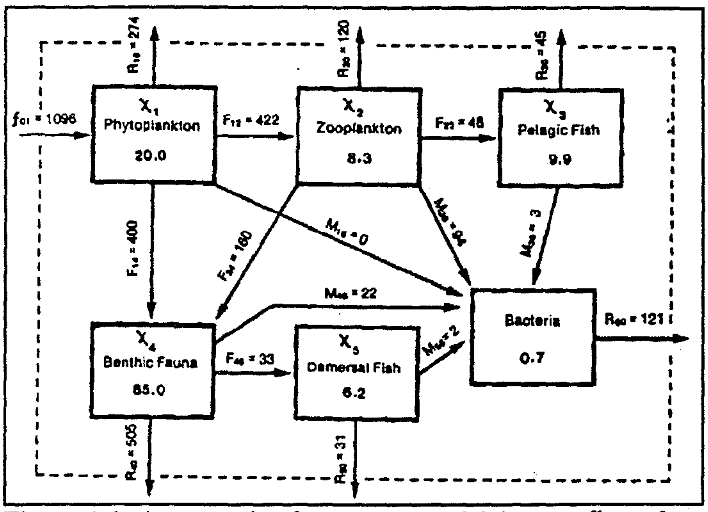

Figure 2.1: An example of a systems model (energy flows for the English Channel. Allen, 1986).

Reductionist (or conventional) approaches to solving complex problems reduce the problem into smaller parts that are easier to cope with i.e. the same way that ecosystems are analyzed (United States Environmental Protection Agency, 1991). For example, the problem of poor water quality might be approached in terms of smaller or 'reduced' problems of phosphate inputs, biological oxygen demand, nitrate inputs, PCB's, DDT contamination and so on (Science Advisory Board, 1978). The part-problems are defined by specialists, usually in numerical terms, such as phosphate or DDT concentrations. The solutions reflect the values of the specialists' discipline that defined the problem (Heerdegen and Rozier, 1990). The desirability of solutions is usually defined in numerical terms, such as cost/benefit ratios (Hunt, 1985). The certainty that is implied by numbers and numerical analysis leads reductionists to the view that nature is controllable (Lovitt, 1977), and reductionist solutions are often an attempt at controlling nature (Holling, 1978).

2.5.2 Reductionism and sustainable management: Conceptual compatibility

A sustainable approach **must** acknowledge that people are connected with the environment and are part of an ecosystem i.e. depend upon The Biosphere for their wellbeing.

In a reductionist approach the term ecosystem means the 'green environment' or 'non-human' aspects, such as forests, rivers and lakes (Vallentine and Hamilton 1987). Humans are viewed as being separate from the environment, because the environment can be 'objectively' observed, and ecosystems are viewed as "systems-external-to-man" (Science Advisory Board, 1978, p1). The reductionist approach is therefore incompatible with the primary principle for sustainable management.

Reductionist approaches also fail the criteria for sustainability.

- **Integrated knowledge:** Reductionist methods quantify ecosystem components. However, components of ecosystems can be difficult to quantify due to complexity, while some components of ecosystems can only be described in qualitative terms, such as 'beauty', and cannot be quantified[7]. In addition, reductionist scientists have a very narrow field of expertise and find it difficult to integrate knowledge from other fields of expertise, and communicate with specialists in other disciplines and the public (Timberlake, 1989). For example, there is little contact between disciplines in most universities in New Zealand[8].

- **Holistic Perspective:** Reductionist approaches tend to look at issues without considering the implications or the context within which an issue is placed. For example, the debate on a minimum flow on the Wanganui River focused on in-stream and out-of-stream uses, but the broader issues which set the context for the debate, such as society's demand for electricity and the issue of energy conservation, were scarcely discussed[9].

- **Ecological Actions:** Reductionist approaches tend to focus on the parts in an ecosystem rather than the connectivity between parts (Chorley and Bennett, 1978).

- **Anticipatory and preventative actions:** Preventative and anticipatory actions focus on possible outcomes from decisions (Simonis, 1984). It is difficult to predict possible outcomes using quantitative models of ecosystems, because the models are simplified and therefore distorted versions of reality, due to complexity inherent in ecosystems. In addition, numerical models of ecosystems can exhibit oscillatory and chaotic behaviour making predictions about possible outcomes meaningless (Levin, 1989).

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[7] The failings of cost-benefit analysis, which attempts to integrate quantitative and qualitative knowledge, are discussed in Section 2.5.3.

[8] Based on my discussions with academic staff in universities.

[9] See evidence presented to a Wanganui-Rangitikei Regional Water Board Tribunal in 1988, and the Planning Tribunal in 1989-90.

- **Ethical actions (respect for other life forms):** Management strategies that are based on reductionism are unlikely to be 'ethical' because nature is seen as being separate from humans. Nature is also considered to have no intrinsic value[10]; nature is just a resource to be used by humans.

At the conceptual level reductionist approaches to management are not compatible with the concept of sustainable management.

2.5.3 Reductionism and sustainable management: practical compatibility

In practice, reductionist approaches have led to unsustainable outcomes. There is evidence of an ever increasing range of 'environmental' and social problems that defy easy solution and are difficult to define. O'Riordan (1973) refers to these as 'meta problems', and these include issues such as waste disposal, conflict between different users of a resource, the accumulation of toxic substances in the food chain.

The reductionist approach to solving meta problems firstly reduces the ecosystem into small parts, secondly, reduces 'the problem' into smaller problems or 'puzzles', ~~thirdly, uses~~ quantitative approaches to define the smaller problems (puzzles), and fourthly, chooses solutions on the basis of numerical analysis (Ravetz, 1988; Hunt, 1988; Regier et al, 1989; Funtowicz and Ravetz, 1990). In practice these four features of reductionism tend to perpetuate meta problems. The reasons are as follows.

Firstly, reducing an ecosystem into constituent parts gives a distorted view of how the 'system' functions. For example, an ecosystem can change its structure (i.e. develop new 'boxes and arrows' - see Figure 2.1) rapidly and in a way that cannot be predicted using a conventional systems model (Allen, 1986)[11]. In addition, it is not possible to identify and accurately assess **all** the relevant parts and relationships in ecosystems (Science Advisory Board, 1978).

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[10] From discussions with economists at Lincoln University, N.Z. Conventional economics is a classic example of a reductionist approach.

[11] Allen (1986) refers to this phenomenon as "The Modellers Nightmare".

Secondly, reducing a 'problem' into smaller parts means that certain aspects of a 'problem' may be solved, but the 'Problem' itself is not tackled. This results in new problems appearing that are related to the original problem, or the problem is merely shifted elsewhere (Skinner, 1989). For example, western society has attempted to deal with certain waste products, such as spent nuclear fuels, while the systematic problem of 'Waste' has not been widely recognised (Ravetz, 1988), with the result that waste related 'problems' are increasing.

Thirdly, quantitative approaches to solving meta problems has resulted in decisions being based on standards or 'magic numbers'[12]. The magic numbers approach is that if an activity does not breach an environmental standard then the activity is safe. Water quality standards are an example of this type of approach.

Magic numbers tend to be unreliable because they are derived from the analysis of quantitative data. Quantitative data and the information provided by numerical analysis can be unreliable for a number of reasons including; inaccuracies in the data, the un-testable nature of models in reality, the influence of researchers' bias, synergistic effects in the natural environment which cannot be anticipated in laboratory experiments, 'chaotic' behaviour of numerical models, and the incomplete picture of ecosystems presented by numerical analysis (Weinberg 1972, Pepper 1984, Funtowicz and Ravetz 1990, Lemons 1986, Levin 1989, Science Advisory Board 1978). Thus, solutions to meta problems that use magic numbers tend to be poorly designed because they are based on inaccurate information.

Fourthly, the desirability of options for solving meta problems are judged using quantitative analyses and criteria. However, uncertainty and complexity associated with natural systems makes this type of approach dysfunctional in all but the simplest of situations. For example, cost benefit analysis, a common decision-making tool that exclusively uses numerical information, has been criticised by researchers as being; 'of limited usefulness' (Stringer 1984), 'an absurdity' (Henderson 1990), and 'a form of suicide' (Janikowski and Starzewska, 1991) due to its flawed fundamental assumptions and its inability to provide mangers with accurate and relevant information about management options.

[12] A term coined by Ruckelhaus (1984), former director of the United States Environmental Protection Agency (USEPA).

Thus, reductionist approaches to management tend not to solve meta-problems (Figure 2.2), and new approaches to management are needed, as opposed to "inconsequential fiddling" with the current management approach (Regier at al, 1989, p113).

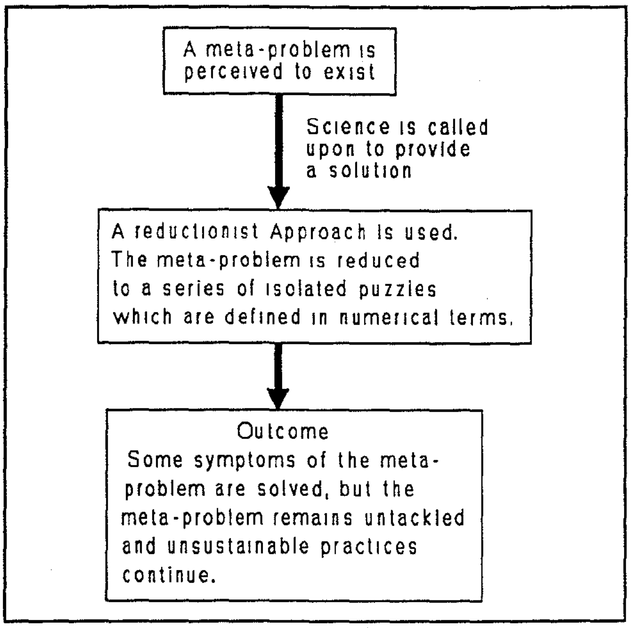

Figure 2.2: The current approach to problem solving.

2.5 Summary: A need for new approaches

The concept of sustainable management demands a change in the way society uses The Biosphere. The current approach to management, reductionism, is incompatible with the concept of sustainability. New approaches to management are required, as opposed to small alterations to existing approaches.

Chapter 3 New approaches, new paradigms

"We must remember that the rationalistic attitude of the west is not the only possible one, and is not all embracing, but is a prejudice and a bias that ought perhaps to be corrected." Jung (1973, p95)

"But many scientists ... fail to understand that every science has metaphysical foundations." (Rich, 1988 p20)

"... the experimental, "hard", sciences contain a strong undercurrent of paradigm-myth, bordering on acts of faith." (Pomeroy et al, 1988, p17)

"Why myths and myth analyses? One simple answer is that many past failures of management have been due to the misapplication of various myths, especially myths about nature." (Timmerman, 1986, p436)

3.1 Introduction and chapter structure

To help ensure sustainable outcomes, systems to manage human uses of ecosystems must be designed using realistic and reliable models of nature. Models of nature are based on a fundamental belief or 'myth' about the structure of nature (Chorley and Bennett, 1978). Reductionism has provided western society with a particular view of the structure of nature but a more comprehensive view is needed for sustainable management.

This chapter discusses the nature of belief systems (paradigms). The origin of the reductionist paradigm is outlined and new belief systems, which provide different approaches to management, are introduced.

There is a substantial literature concerning the reductionist world-view and the nature of paradigms (e.g. Blockley, 1980; Wenz, 1989; Livingstone, 1990; Cosgrove 1990). This chapter briefly outlines the main concepts and aims to provide a lead into the different world-views which are discussed in Part Two of this thesis.

3.2 Paradigms and world views

Western (reductionist) science is a particular paradigm. Drengson (1980) defines a paradigm to be:

> *"... a constellation of models which defines, exemplifies and illustrates the ideals and procedures of science..."*(P 225)

Drengson refers especially to the 'ideals' of western science, which evolved over centuries to the present day. At times individual persons have influenced the shaping of the ideals and procedures.

The ideas of Descartes - a sixteenth century thinker - had a significant influence on later scientists, such as Copernicus, Brahe, Kepler, Newton (Briggs and Peat, 1984). Newton's work 'Principia' is a cornerstone of modern science and the mathematical language developed by Newton, which is based on Descartes' ideals, is still used within nearly all sciences today (quantum physics is an exception). The ideals of Descartes, therefore, influence the models and procedures of science today.

Descartes believed there were two classes of objects in the universe: the observer and the observed. Nature consisted of objects which could be objectively observed by Man and obeyed certain laws. All laws stemmed from a few axioms. Newton took this thinking and applied it to the planetary system. His success at predicting future celestial events gave Descartes' thinking great weight in society at that time.

At the end of the nineteenth century western scientists were supremely confident with their paradigm. Nearly all phenomena could be explained by Newton's laws, together with the laws of thermodynamics and the laws of electromagnetism (Tipler, 1976). However, one phenomenon could not be explained: black body radiation. The explanation of this phenomenon led to the development of a totally new way of looking at the world. The quantum paradigm was developed.

The development of quantum theory has enabled philosophers to argue convincingly against the 'objectivity' of science. Previously, the success of science in explaining and describing the way nature functioned tended to mute any criticisms.

The philosopher Karl Popper (1959) considered that there is nothing absolute in 'objective' science. He suggested that western science does not rest upon a rock solid base of objectivity, but rises out of a swamp very much like a building erected on piles. Popper attributed the success of Newtonian science to the fact that it was applied to isolated systems which existed in stationary[13] states. Systems in stationary states are rare in The Biosphere.

Drengson (1980) considers that a paradigm (Popper's 'building') is based on a 'mythic understanding' or 'piles' driven into the swamp, using Popper's analogy. Techniques, methods of analysis and language develop from the mythic understanding and a paradigm takes shape. Thus a paradigm is a form of understanding of the way the world functions and includes a particular style of language for describing nature.

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[13] In a stationary state the system's parameters do not vary with time, for example the planets orbit the sun continuously.

A paradigm is used to frame questions to ask nature. Science presses nature into providing answers, and nature does not simply 'give' science answers. The questions asked of nature are framed using models, analysis techniques and languages that are developed on the basis of a certain mythic understanding. For example, reductionist science inquires about water quality in numerical terms, such as faecal coliform levels or suspended sediment concentrations.

The answers provided by nature are fitted into certain 'paradigmatic-boxes' provided by the education process (Kuhn, 1970). For example, in a reductionist approach water is considered suitable for swimming on the basis of numerically-formulated water quality criteria, such as faecal coliform concentrations. Scientists become captives of their own models, associated analysis techniques and language, and see the world in a way which confirms their 'mythic understanding' (Drengson, 1980). Therefore scientists do **not** see the world completely objectively.

Different scientific frameworks can be constructed on the basis of different myths (or mythic understanding). The way questions put to nature are framed will vary depending on the myth and the answers will vary also. Scientists working from different paradigms have difficulty communicating; they cannot even agree on what constitutes a valid question to ask nature (Kuhn, 1970).

For example, the traditional Maori and reductionist science approaches to assessing water quality are very different. A reductionist approach considers water quality as a collection of numerical terms; a traditional Maori approach uses the concepts of mauri and taniwhas which represent the quality of the whole water body, not just certain quantifiable aspects. Maori scientists and reductionist scientists tend to disagree on a valid approach for assessing water quality[14].

A paradigm can be likened to a form of art based on a certain myth (Drengson, 1980). For example, the highly developed numerical analysis techniques used in reductionist science can be likened to a highly developed painting technique, such as impressionism. A paradigm based on the myth that the observer and observed are separate, as is the case with western

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[14] For example, see evidence concerning minimum flows in the Wanganui River presented to a Regional Water Board Tribunal in Taumaranui, 1988, and the Planning Tribunal, 1989,90.

science, is not a uniquely correct 'artform', just as impressionism is not the 'correct' form of painting. Other paradigms based on different myths exist and may provide may decision-makers with different views of the world, just as different painting techniques provide different views of nature, and these different views may be more helpful for making decisions that have sustainable outcomes.

3.3 Suggested approaches to management

Chapter 2 concluded that the reductionist approach is unlikely to provide society with ways for managing human uses of ecosystems in a sustainable manner. A new approach is needed. In New Zealand we have two clearly defined cultural bases to call upon: Maori and Western.

The Maori approach to managing The Biosphere in general and water resources in particular has been developed to suit New Zealand's physical conditions and the needs of Maori society over the last 1000 or so years.

In western society the Gaia hypothesis, proposed by the atmospheric chemist James Lovelock in the early 1970's (see Lovelock, 1979), provides a different view of the way The Biosphere functions. The paradigm which is forming around the Gaia hypothesis recognises nature's complexity and does not rely on reductionism as a means of simplification (Timmerman, 1986).

In the remainder of this thesis, the Gaia hypothesis will be used to formulate an approach to management and the traditional-Maori approach to management will be outlined. These two approaches will be contrasted and synthesised into a 'unified' approach.

Reductionist scientists should not discount these alternative world-views because they are based on 'mythical' or 'metaphysical' beliefs, a common reaction amongst reductionists to indigenous science (Thrupp, 1988) and the Gaian view of nature (Watson, 1988). Reductionism itself is based on 'mythical' or 'metaphysical' beliefs that nature consists of objects that can be objectively studied and that relationships between objects can be expressed using mathematical (often linear) relationships (Ravetz, 1986).

3.4 Summary

Approaches to management are based on a fundamental belief about the structure of nature. Reductionism represents a particular view of nature, but other views are possible and valid. Two world-views have been chosen from which to synthesize a myth on which to base a management approach; the Gaia hypothesis, which provides a new western world view, and the traditional Maori worldview. A key aspect of developing a new approach is forming a new 'language'. Words are the building blocks of thought, and different approaches to viewing nature require a change in our vocabulary (Tickell, 1991).

Part Two

Developing an approach

Chapter 4 A Gaia-based approach

"... it now seems possible that the Gaia hypothesis will begin to give some real coherence to what has hitherto been a rather complex and confused set of ideas about the natural environment." (Ravetz, 1988, p134)

"... it is worth reiterating at this stage the need to move our demands on systems analysis away from questions purely about things towards questions about flows and processes." (Chorley and Bennett, 1978, p545)

"... we must acknowledge the limits of our ability to predict - the ecologists' uncertainty principle - and be prepared to manage in the face of that uncertainty. That will require the development of more sophisticated and flexible approaches to risk assessment and management. ... The fuzzy boundary between science and policy justifies, even necessitates, public involvement in the decision-making process." (Levin, 1989, p7)

4.1 Introduction and chapter structure

Sustainable management systems require realistic and reliable models of nature. At present there is not a consistent view amongst western-scientific disciplines as to how nature functions. Ecology (the study of ecosystems) is in a state of crisis (di Castri, 1986). For example, there is intense debate between reductionist and systems ecologists about the way ecosystems function (McIntosh, 1985).

However, there is increasing convergence about how nature functions across many different disciplines, such as atmospheric chemistry, sub-atomic physics and biology[15] (e.g see Capra, 1983). The emerging paradigm uses the Gaia hypothesis as an organizing principle, is consistent enough to provide the framework necessary to understand how ecosystems function (Holling, 1986), and can be used to design sustainable systems of management.

This chapter can be divided into two major parts. Firstly, concepts are developed to describe how ecosystems function. Secondly, a management approach is developed using the concepts.

An understanding of how ecosystems function is based on the Gaia hypothesis. The Gaia-based view of The Biosphere suggests that ecosystems are 'open-systems' and concepts developed in open-systems research are used to explain how ecosystems function. Human uses of ecosystems are discussed and sustainable ecosystem use is defined using the Gaia-based concepts.

The approach to management is then developed using the Gaia-based concepts. Methods of implementing the approach are discussed. The sustainability of the Gaia-based approach is assessed using the criteria developed in Chapter 2.

[15] Unfortunately the proponents of the 'new world view' (or myth) are themselves involved in factionalized infighting but this is to be expected as new ideas are argued through the scientific arena. See for example Goldsmith (1988), who condemns some researchers on the basis of their, as yet, incomplete ideas and models.

4.2 Description of The Gaia hypothesis

This section describes the Gaia hypothesis and outlines the evidence that supports the hypothesis.

4.2.1 The Gaia hypothesis

The Gaia hypothesis presents a radical change in the way western scientists view nature. While it can be argued that the Gaia hypothesis only represents a myth or metaphor, our view of the way nature behaves is formulated on the basis of myths[16] (Abram, 1988).

The Gaia hypothesis states that:

> *"The temperature and composition of the Earth's surface are actively regulated by the sum of life on the planet - the biota. Major aspects of the Earth's surface are dynamically maintained in frantic stability."* (Margulis and Lovelock, 1989, p1)

James Lovelock is credited with formulating the Gaia hypothesis. However, many people throughout history have suggested that life on earth exists as a single system or organism, including many writers in the twentieth century (Grinevald, 1988). Thus, the Gaia hypothesis is being accepted because new views of The Biosphere are needed, and not because it represents a new or novel idea.

Lovelock began to seriously think about life on earth when developing techniques to establish whether there was life on Mars. The presence of entropy reduction processes seemed a likely line of enquiry for detecting life (Lovelock, 1979). Life reduces entropy, whereas in the absence of life entropy increases, according to the thermodynamic laws of physics.

Lovelock was aware that a few physicists had already tried to define life using ideas about entropy reduction (Lovelock, 1979). However, this approach had proved to be of limited usefulness because entropy reduction was difficult to measure. For example, it did not seem possible to measure the entropy reduction associated with a living creature such as a cat or a tree.

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[16] Myths are discussed in Chapter 3.

Lovelock next considered how life functions in terms of the use of materials. Living organisms take raw materials and produce waste. This process needs to be cyclical for life to sustain itself. Therefore raw materials and waste products must be transported by the 'conveyer belt' regions of a planet such as the atmosphere. Lovelock postulated that concentrated entropy reduction may spill over into the atmosphere and alter its composition. The Earth's atmosphere contains large amounts of gas at relatively high potential energy, such as oxygen. According to the laws of thermodynamics the reactive gases ought not to be present and the atmosphere should contain relatively inert compounds such as carbon dioxide. Thus, Lovelock had discovered a test for life: Analyze the state of the atmosphere relative to the state predicted by the laws of equilibrium thermodynamics.

To test this theory the atmospheres of the neighbouring planets of Mars and Venus were compared to Earth's atmosphere (Table 4.1). The atmospheres of the neighbouring planets do not contain highly reactive gases. Earth's atmosphere is anomalous because reactive gases, such as oxygen, are present in large quantities. Lovelock postulated that life maintains the chemical disequilibrium in the atmosphere. The Gaia hypothesis was formulated.

Atmospheric Gas	Venus	Earth	Mars
Carbon dioxide	96.6	<1	95
Nitrogen	3.2	78.1	2.7
Argon	trace	<1	1.6
Oxygen	<1	20.9	<1
Water	<1	<1	<1

Table 4.1: Chemical constitution of Mars', Earth's and Venus atmosphere shown as percentages (data from Margulis and Lovelock, 1989).

4.2.2. Gaia: a controlling mechanism

So far, the 'Gaia hypothesis' represents nothing more than what we already know. As Gould (a biologist) states in response to the Gaia hypothesis:

"Obviously the atmosphere reacts with life; its oxygen content is dependent on life. But we've known this for a long time." (quoted in Abram (1988), p119).

However, Lovelock considers that the atmosphere does not just react with life, but the atmosphere is a biological construction and is controlled by life. The atmosphere is an extension of a living system and is designed to maintain the environment in a particular state, like the fur on a cat is designed to keep a cat warm (Lovelock 1979).

Lovelock and other researchers have begun to define how Gaia functions and controls the environmental conditions on Earth, such as the salinity in the oceans and pH of soils. Researchers are discovering that large quantities of highly reactive gases, such as ammonia and methane, are produced by Gaia, and that these form the basis of the environmental control system on Earth (Lovelock and Epston, 1986). The global cycling of nutrients is termed 'nutrient cycling'. Nutrient cycles are now recognised by some scientists as being an expression of life; the metabolic structure of Gaia (Moore et al, 1989). Thus, the Gaian system behaves as if it were a living entity with the constituent parts co-operating to control certain environmental conditions much as the different parts of warm blooded animals co-operate to regulate body temperature (to use an analogy).

4.2.3 Gaia and conventional (reductionist) science: Daisyworld

Despite the increasing evidence for the reality of the Gaia concept, mainstream science has been slow to embrace the Gaia hypothesis. 'Conventional' scientists argue the Gaia hypothesis is teleological[17] because the hypothesis suggests that life has some underlying purpose which has been designed into it at the very beginning. Scientists consider that this idea belongs to religion, not science (Watson, 1988).

The criticisms by other scientists forced Lovelock and other researchers to think again about Gaia (Margulis and Lovelock 1989). They responded by developing 'Daisyworld', a model which shows that growth of organisms could control environmental conditions such as temperature[18]. The model was based on the assumption that there is a close relationship between biota and global environment; an assumption that mainstream science was happy to accept.

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[17] teleology: Doctrine of final causes, view that developments are due to the purpose or design that is served by them (Oxford Concise Dictionary, 1976, 6th ed.).

[18] The choice of model arose from a belief that the sun's luminosity had increased over the millennia (Gribben, 1986), which should have increased Earth's temperature, according to the laws of physics. However, Earth's temperature is thought to have remained fairly constant over the millennia (Henderson-Sellers, 1986), suggesting that the Earth's temperature has been controlled (Lovelock and Epston, 1986).

Daisyworld is a cloudless planet with an atmosphere capable of trapping heat (long-wave radiation) and passing light (shortwave radiation), much as Earth's atmosphere does. Two species of plants cover Daisyworld's surface entirely: white and black daisies. No other species are present. White daisies reflect light. An increase in their numbers cools the planet. Black daisies absorb light. An increase in their numbers heats the planet. White daisies grow slightly better in warmer temperatures because they are heated less by the sun. Black daisies absorb heat from the sun and the optimal temperature for them is slightly less than for the white daisies. If white daisies grow to cover too much of daisyworld the atmosphere cools which limits white daisy growth. Similarly black daisies are controlled. The proportion of black to white daises is self limiting.

The solar luminosity was altered in Daisyworld. Daisyworld's atmospheric temperature remained relatively constant because the proportions of black and white daisies changed, minimising the effect of a change in luminosity (Figure 4.1). The temperature regulation is a consequence of the feedback mechanisms within Daisyworld's Biosphere. Thus the stability of Earth's temperature over the millennia can be explained in terms of feedback mechanisms.

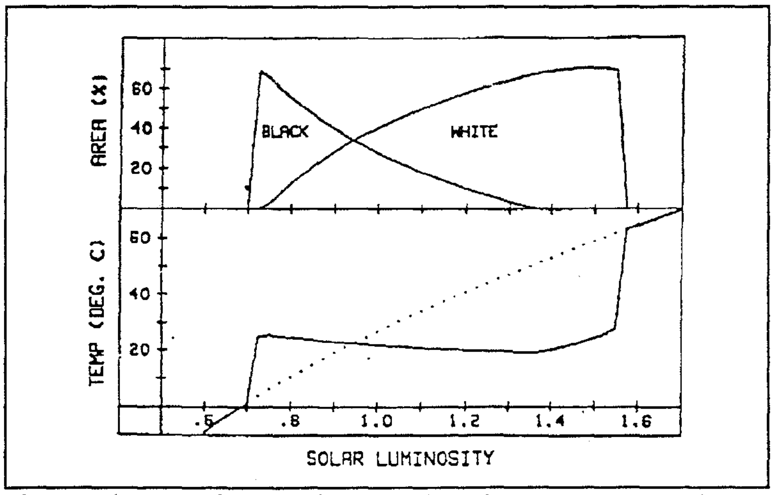

Figure 4.1 Areas of daisies (top graph), and temperature, as solar luminosity increases on Daisyworld. Dashed line represents temperature without daisies (Watson, 1988).

The Daisyworld model shows that feedback loops between the global environment and biota can control environmental conditions. The Gaia hypothesis is shown not to be teleological, and the Gaia hypothesis is being accepted by Western science as a valid way of viewing The Biosphere (e.g. see Great Lakes Science Advisory Board, 1991, p33).

4.2.4 The Gaia Hypothesis: Key Points

The Gaia hypothesis puts forward two important points with regard to the way nature functions:

- nature controls the environmental conditions on the planet, such as global temperature and salinity of the ocean, through the process of feedback,
- nature has a power to organise which is beyond the sum of its individual parts.

These two points provide a very different picture of the way nature functions compared to the picture provided by conventional (reductionist) science. Reductionism suggests that nature can be understood through analysis of constituent parts and that nature adjusts to environmental change, rather than controlling environmental conditions (Abram, 1988; Mann, 1988). Thus, the Gaia hypothesis presents a radical change in the way western science views how nature functions.

4.3 How ecosystems function as implied by the Gaia hypothesis

The Biosphere consists of a network of interrelated ecosystems that contain and support life and maintain the structure of the Biosphere. This section assesses how ecosystems function.

Ecosystems have the following characteristics:

- they have permeable boundaries i.e. ecosystems are involved in the global cycling of nutrients and energy.
- they are far from thermodynamic equilibrium,
- they have a dynamic structure or organisation which persists over time.

Past approaches to understanding how ecosystems function can be broken into two categories; population dynamics, and systems analysis[19]. Population dynamics attempts to understand nature by considering its parts (MacIntosh, 1985), is therefore, and thus tends to present a distorted view of the way nature functions (Chapter 2).

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[19]These two branches of ecology (the study of ecosystems) were identified in 1975 by Smith and MacFadyn, former presidents of the American and British Ecological Societies respectively (MacIntosh 1985).

Systems analysis of ecosystems (ecosystem ecology) uses a range of concepts to describe ecosystems, including; energy use and entropy reduction, trophic levels, resilience, stability and diversity. These concepts have not been useful for explaining how ecosystems function. For example, ecosystem energetics and trophic levels have not provided an understanding of how or why ecosystems maintain their structure (Nicolis and Prigogine 1977, Pomeroy et al 1988); the terms 'stability' and 'resilience' cannot be coherently defined[20] (Holling, 1986); organisms cannot be conveniently placed into hierarchical 'trophic levels' (Mann, 1988). Pomeroy and Albert (1988) sum up the situation:

" ... *changes in our* [ecosystem ecology] *paradigm can be expected."*

Thus, neither conventional ecosystem ecology nor population dynamics is heavily drawn upon to provide an understanding of how ecosystems function.

Western scientists are developing new and "radical" (Mann, 1988, p309) theories about how ecosystems function. Much of this theory has developed out of research in the area of chemical thermodynamics, and has focused on chemical systems that have permeable boundaries, are far from thermodynamic equilibrium and have a structure that persists over time i.e. similar features to ecosystems. The thermodynamic-based concepts have proved valuable for understanding how ecosystems function[21], if carefully applied[22], and are used in this section to provide insight into how ecosystems function.

4.3.1 Description of open-systems

Systems that are structured, far from equilibrium and have permeable boundaries are termed 'open-systems' (Hugget, 1986). An ecosystem can be viewed as an open-system, or as a collection of open-systems.

An open-system should be viewed as an independent 'framework' in which the parts are placed (Angyal, 1941). The parts in the framework are in close contact allowing flows of

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[20] There is a large ecological literature debating these two concepts, but little agreement.

[21] See Allen (1985), Allen and McGlade (1986) for the use of thermodynamics-based concepts in ecology; see Mann (1988), Keddy (1989 and 1991) for discussion of the use of the concepts.

[22] This caveat is based on A.N. Whitehead's (1929) philosophy of organism.

energy and nutrients (and information) to occur within the system. The structure (or framework) of an open-system cannot be understood by analyzing the constituent parts. Both the parts and their relationships combine to give an open-system its structure (Capra, 1983).

The arrangement of open-systems in an ecosystem can be imagined in terms of a tree structure (Figure 4.2). The order at one level is a consequence of self-organization and structure at both larger and smaller levels (Capra, 1983). Thus the levels in an open-system can be viewed as being in a state of mutual dependence and co-operation, relying on each other to provide the structure of the 'whole'. In the case of ecosystems the 'whole' is the Biosphere (Figure 4.3).

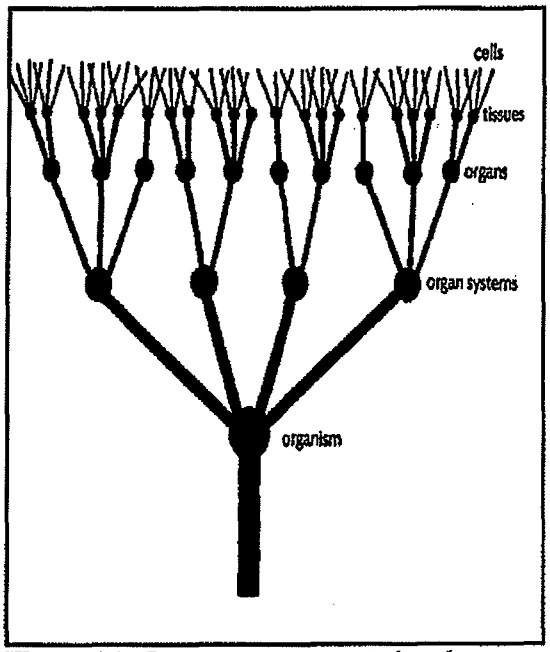

Figure 4.2: Systems tree representing the various levels of complexity in an open system which in this example is an organism (Capra, 1983).

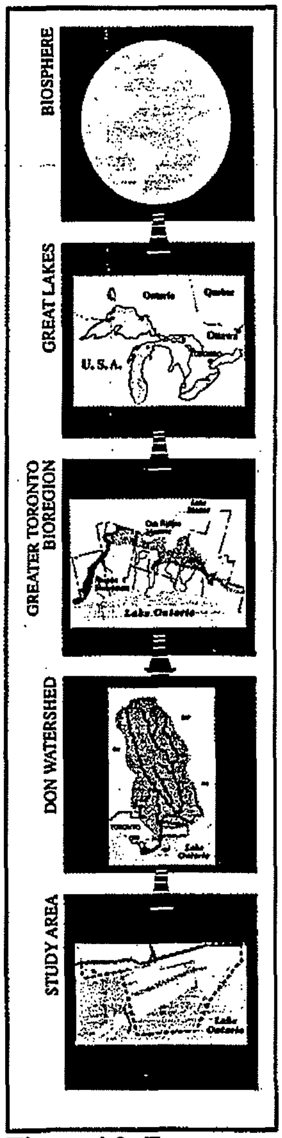

Figure 4.3: Ecosystems and levels of complexity (Barrett and Kidd, 1991).

4.3.2 Feedback loops

An open-system uses feedback loops to maintain its structure while external conditions change, as shown in the Daisyworld example. The term 'feedback loop' encompasses both the relationships and parts of an open-system (Figure 4.4).

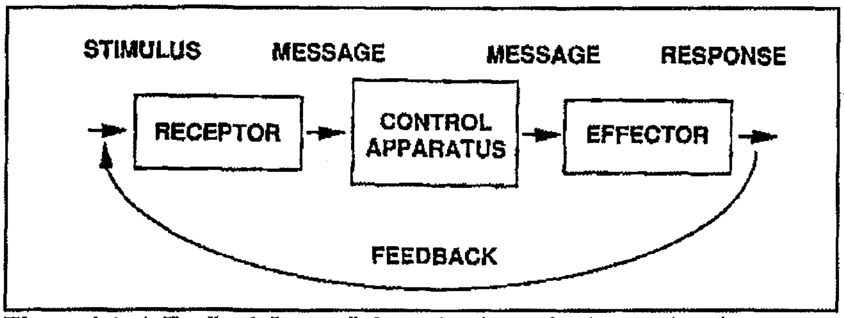

Figure 4.4: A Feedback Loop. Information is received and relayed to a control apparatus which directs an effector. The results are fed back into the system (Oates, 1989).

Feedbacks work to control the way a system functions by introducing the results of the system's past performance back into the system (Weiner 1970). An open-system can be imagined as being steered from the inside (using feedback loops) as it reacts to changes in external environmental conditions.

Within a feedback loop materials may be processed a number of times by different parts. In ecosystems (complex open-systems) materials can go through complicated tortuous feedback processes which ecologists refer to as 'cycles' (Figure 4.5). In an ecosystem there are many different cycles operating simultaneously and interacting with each other.

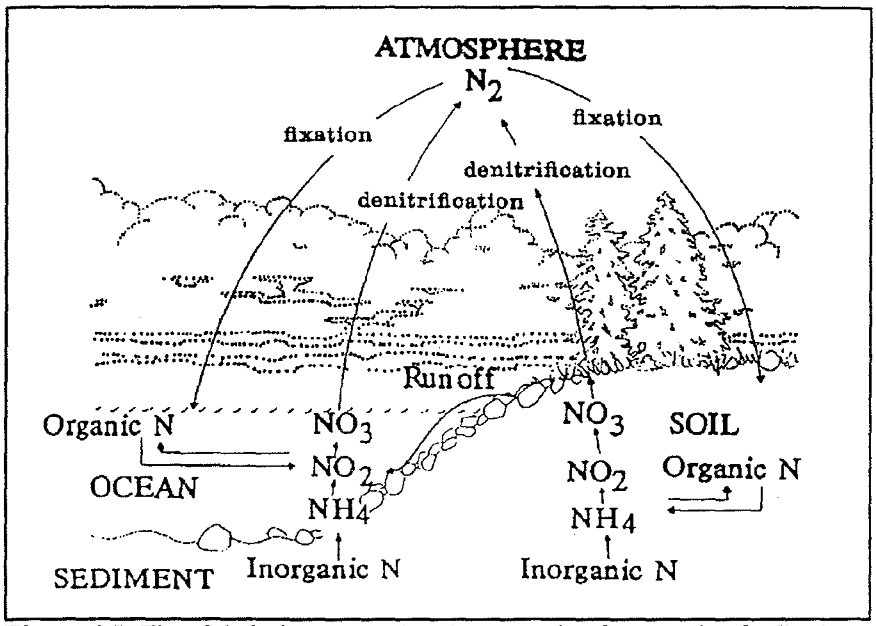

Figure 4.5: The global nitrogen cycle. An example of a complex feedback process in a large ecosystem (after Stolz et al, 1988).

Feedback loops can have different response times (Figure 4.6). The variation in response times and the interconnections in ecosystems cause flows of materials to constantly change. This phenomenon is observed as fluctuations in ecosystems (Holling (1986); Odum, 1988; Figure 4.7). In most instances the fluctuations in open-systems are not periodic but exhibit seemingly random behaviour which researchers are now discovering can be fitted into patterns (Gleick, 1987).

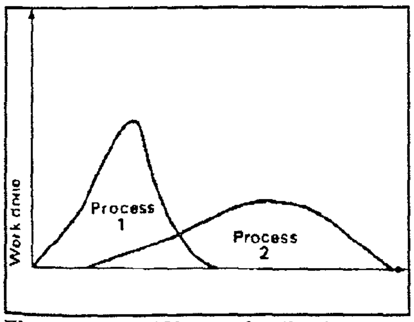

Figure 4.6: Different feedback processes have different response times. (Bottom axis represents time. Adapted from Hugget, 1985).

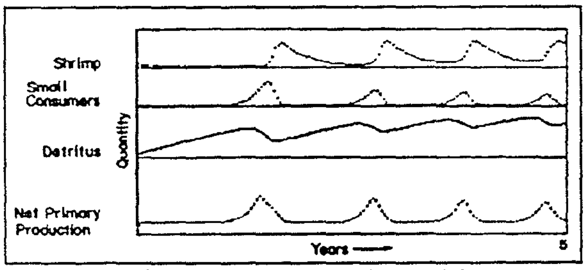

Figure 4.7: Simulation showing 'pulses' in an estuarine ecosystem (adapted from Odum 1987).

The concept of fluctuations is critical to understanding how ecosystems function. For example, in the Mohakatino River in North Taranaki the adjacent wetlands act as a 'safe haven' for native fish when the suspended sediment load in the river is high, but during normal flows the adjacent wetlands contain few fish (Coffey and Williams, 1991). The importance of the wetland for sustaining the native fishery can only be understood using the concept of fluctuations, because it is the increase or 'fluctuations' in fish numbers in the wetland that shows the wetlands' importance for maintaining the fishery.

Human impacts on ecosystems will be 'patchy' in both space and time as a consequence of the different response rates of feedback loops (Holling, 1978; Figure 4.8). For example, if the wetlands adjacent to the Mohakatino River were drained the effects on the native fishery would not become apparent until an event happened that increased the suspended sediment load, which could occur a considerable time after the wetlands were drained.

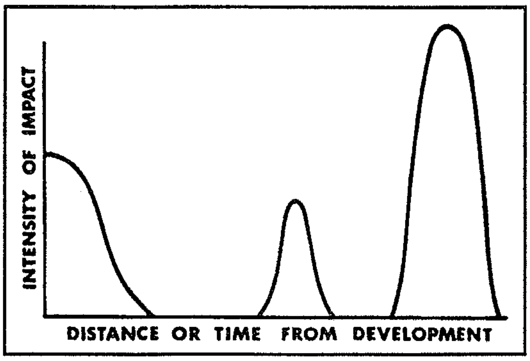

Figure 4.8: Changes in an ecosystem are 'patchy' in both space and time (Adapted from Holling, 1978).

4.3.3 Self-organization and bifurcations

Feedback processes enable open-systems to 'self-organize'. Self organization means that the structure of an open-system is determined by the relationships within the system[23].

Fluctuations can result in a self-organizing (open[24]) system becoming unstable and reorganizing its structure in a sudden and unpredictable manner. This process is called a 'bifurcation' (Figure 4.9). At a bifurcation point the system rapidly changes into one of a number of different configurations. The structure the system adopts are determined by the conditions precisely at the time the system reaches the bifurcation point (Prigogine and Stengers, 1984). Thus, when an open-system is poised at a bifurcation point the tiniest

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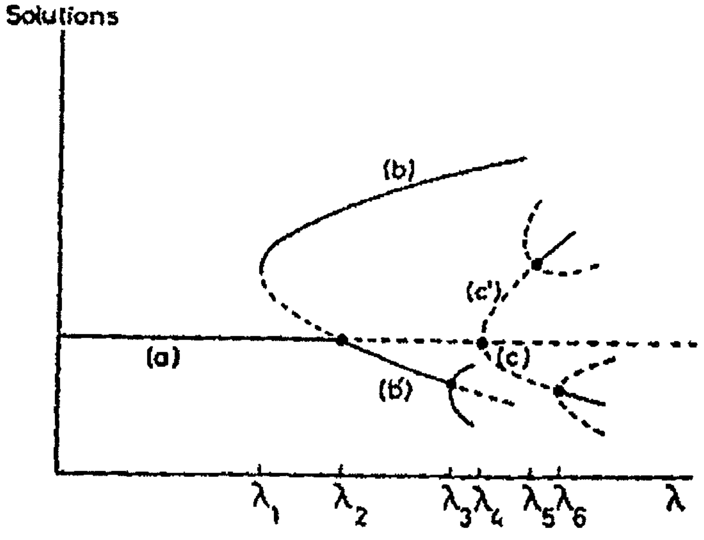
[23] This view is at odds with the conventional reductionist view that the structure of an ecosystem is imposed by conditions outside of the system (Mann, 1988).

[24] Open-systems can also be referred to as 'dissipative structures', because they break down other structures (e.g. energy, nutrients), process the components and dissipate degraded waste products (Prigogine and Stengers, 1984).

fluctuation can change the system into any one of a number of different configurations.



Bifurcation diagram. Steady-state solutions are plotted against bifurcation parameter λ. For $\lambda < \lambda_1$ there is only one stationary state for each value of λ; this set of states forms the branch a. For $\lambda = \lambda_1$ two other sets of stationary states become possible (branches b and b').

The states of b' are unstable but become stable at $\lambda = \lambda_2$ while the states of branch a become unstable. For $\lambda = \lambda_3$ the branch b' is unstable again, and two other stable branches appear.

For $\lambda = \lambda_4$ the unstable branch a attains a new bifurcation point where two new branches become possible, which will be unstable up to $\lambda = \lambda_5$ and $\lambda = \lambda_6$.

Figure 4.9: Bifurcation diagram (Prigogine and Stengers, 1984)

The Japanese art of paper folding (origami) provides an illustration of the bifurcation concept (Figure 4.10). A fold in a sheet of paper results in the sheet of paper having a different shape. Folds are equivalent to fluctuations (Allen, 1986). Multiple folds (fluctuations) can create a range of different shapes (or forms) that can only be distinguished in qualitative terms, such as a horse or a seagull. In this illustration the observer uses his or her cognitive facilities to dictate certain 'allowable' forms. This is similar to the case with ecosystems where the environment dictates certain 'allowable' forms i.e. forms that are compatible with the environment in which they evolve (Allen, 1986).

Forms, such as 'horse' or 'seagull', only become clearly identifiable at precise moments **in** the folding process. The essence of a form is contained in **both** the folds **and** the order in which the folds were made. Thus, the **timing** and **order** of events determine the form or structure in an open-system.

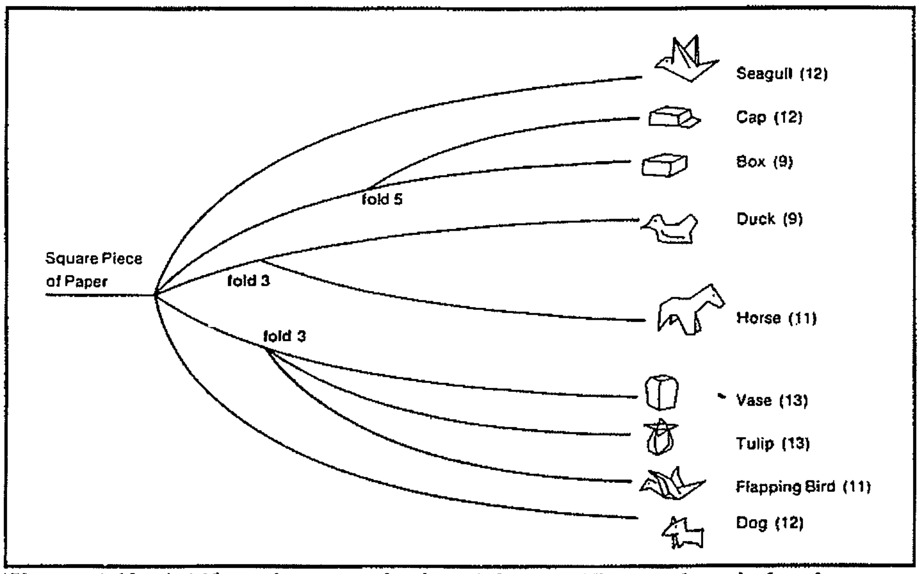


Figure 4.10: A bifurcation tree of origami forms. The numbers in brackets represent the numbers of folds (Allen, 1985).

The belief that nature has observable, but qualitative, 'form' is significantly different to the reductionist view. Reductionism cannot recognise 'form' in an object because form is essentially qualitative. For example, a reductionist assessment of the origami 'seagull' would describe the seagull merely as a piece of folded paper, the type and quality of which could be measured objectively but which is objectively (quantitatively) indistinguishable from "seagull", "horse", "dog", "duck" in Figure 4.10 (Allen, 1986). The concept of form (also referred to as pattern in this thesis) is crucial for understanding how open-systems (ecosystems) function.

The concept of forms and bifurcations can be readily used to understand how ecosystems function. For example, the Mackenzie Basin system, which essentially comprises relationships between sheep, tussock grass, rabbits and climate, was finely poised. A drought (fluctuation) resulted in the system radically changing, suiting the rabbits (Williams, 1991). The system is approaching another bifurcation point. Windstorms (fluctuations) now erode the soil reducing the productivity of the land, which will ultimately cause a decline in rabbit numbers. However, the presence of wilding pines may create another bifurcation and the system could turn into a large pine forest rather than an eroded 'desert' (Figure 4.11).

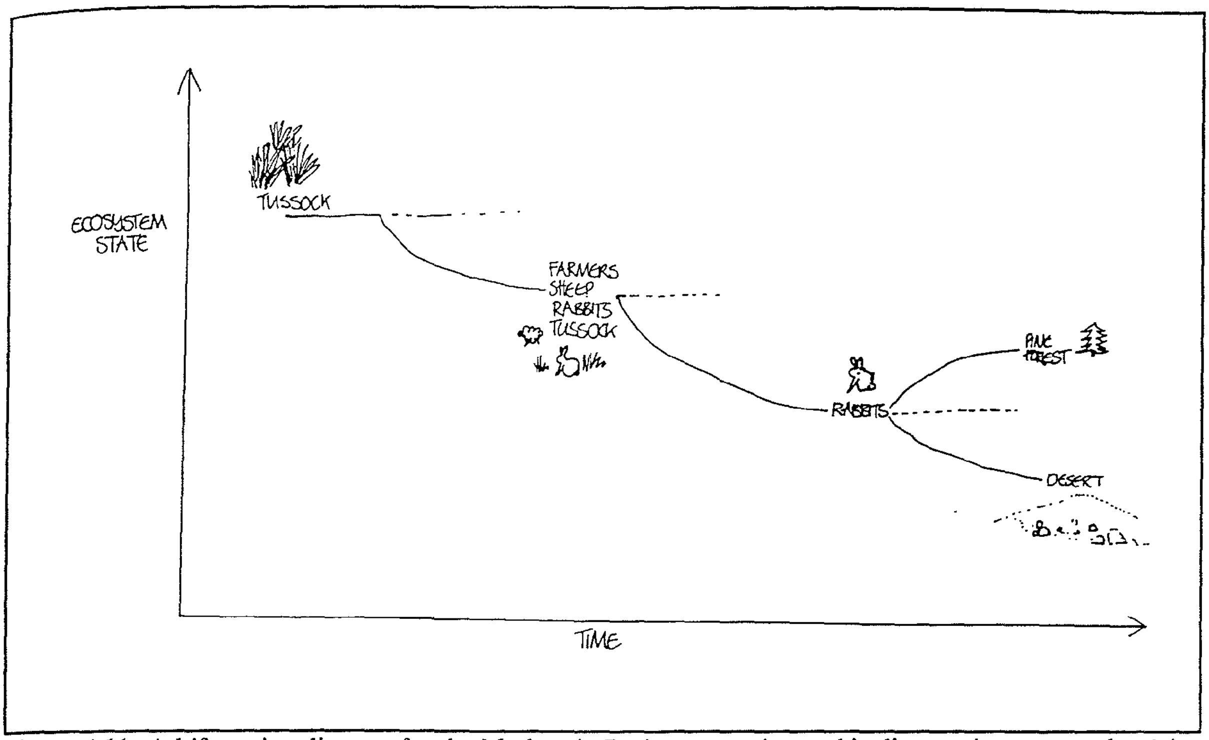


Figure 4.11: A bifurcation diagram for the Mackenzie Basin system (note: this diagram is conceptual only).

The bifurcation concept has two obvious advantages over reductionist approaches for understanding how ecosystems function. Firstly, the concept provides a 'humans-in-the-ecosystem' perspective[25], thus allowing humans to be modeled as integral features of an ecosystem (Allen and McGlade, 1986). For example, in the MacKenzie Basin the advent of pastoralism can be modelled as a fluctuation that resulted in the system changing from tussock, to tussock-sheep-rabbits, and ultimately rabbits.

Secondly, wholesale changes to an ecosystem **over time**[26] can be described. For example, the way the MacKenzie Basin has changed from tussock to rabbits can be understood.

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[25] Rather than the reductionist view which is humans-separate-from-the-ecosystem (Chapter Two).

[26] In a reductionist approach an ecosystem might be modeled in terms of boxes and arrows, but over time ecosystems can develop new boxes and new arrows, making the systems model obsolete. Allen (1986) refers to this phenomenon as "The Modellers Nightmare".

4.3.4 Randomness and pattern

The bifurcation concept suggests that the structure of ecosystems is determined by chance events (Prigogine and Stengers, 1984), such as a drought occurring at strategically times and places i.e. both the timing and sequence of fluctuations is important. The suggestion that nature is a product of chance implies that outcomes from decisions cannot be predicted, which has serious implications for resource management. But some researchers suggest that the way ecosystems function can be understood in terms of patterns (e.g. Goldsmith, 1988; Ho, 1988), while others suggest that nature might not be able to be predicted with absolute certainty, but can be understood in terms of historical occurrences or an 'unfolding process' (Jantsch, 1982).

These two views are now discussed. Firstly, the concept of scale is used to link patterns and randomness, secondly, the concept of nature as an unfolding process is described.

4.3.4.1 The importance of scale

The different views (pattern and randomness) need to be considered in the context of scale. Nature appears to change its behaviour depending on the scale used to observe it (Shugart and Urban, 1988; MacIntosh, 1985).

At small scales bifurcations can be understood in random terms (Prigogine and Stengers, 1984; Jantsch, 1982); however, over larger scales bifurcations must be understood in terms of pattern (Jantsch, 1982). For example, viewing the MacKenzie Basin system during the 1980's (small scale) would suggest that a drought (random event) caused the rabbit population to explode (Williams, 1991), but the underlying cause of the explosion in rabbit numbers was the pattern of pastoral land management (Williams, 1991), which can only be appreciated in terms of a larger time scale.

The origami bifurcation diagram (Figure 4.10) provides another way of explaining the crucially important pattern/randomness concepts. At any given point on the bifurcation diagram only certain future forms (patterns) are possible, but which form will eventuate is unknown (i.e. described in terms of chance). For example, at precisely the point of lower 'fold 3' (refer Figure 4.10), "vase", "tulip", and "flapping bird" are the only possible future forms, but the future form can **only** be stated as being any **one** of these three forms. Thus, a pattern exists because there is a finite range of forms, but there is randomness also because it is not possible to precisely determine the final form. Randomness and pattern exist simultaneously at a bifurcation point. Nature may thus have some type of predictability after all, a view also put forward by the systems ecologist Holling (1986).

Holling (1986) develops the concept of 'slow' and 'fast' variables to describe how ecosystems function, and Holling's approach provides a useful framework for understanding the pattern/randomness concepts. A variable is an arbitrarily defined part of an ecosystem, such as a forest, an algal bloom, or a rabbit population. Fast variables respond to changes in environmental conditions very quickly, for example, the growth of an insect population, the intensity of forest fires, an algal bloom. Slow variables react slowly, for example the growth of trees, human populations, fish populations. Fast and slow are relative terms and cannot be defined absolutely.

Holling's view of how ecosystems function is similar to the bifurcation concept, and slow and fast variables are very similar to 'pattern' and 'randomness'. Slow variables create situations which are 'accidents waiting to happen' (fast variables) but when and where accidents occurs depends upon the chance occurrence of fluctuations (Holling 1986). For example, in the MacKenzie Basin land management patterns created an 'accident waiting to happen', and a drought in the mid-1980's caused the accident to happen.

Thus, pattern and randomness are complementary ways of viewing how ecosystems function. Nature is predictable in a sense, but it is not predictable in an absolute sense. This view is profoundly different to the reductionist view, which sees nature as being as predictable as, in Descartes' words, "a machine" (Quote beginning of Chapter Two).

4.3.4.2 Nature as an unfolding process: A Gaia-based cosmology

The influence that fluctuations have on an ecosystem suggests that nature can be viewed as an unfolding dynamic process i.e. ecosystems progress down the branches of a bifurcation tree. Thus, ecosystems are constantly adapting to change by altering their internal organization. In a sense ecosystems are **learning** as they go along (Timmerman, 1986) in a 'creative' manner (Jantsch, 1982).

As ecosystems unfold their future pattern cannot be predicted with certainty (Jantsch, 1982; Allen, 1986). But this does not imply that ecosystems evolve in a random way, rather the future state of ecosystems is indeterminate. Reference to a bifurcation diagram (Figures 4.10-4.12) may help in understanding the unfolding concept. As an ecosystem travels along branches of a bifurcation tree only certain options are available to it at a bifurcation point. The options are determined by its position in the bifurcation tree i.e. all past events. In effect, ecosystems retain a memory of all past events (Timmerman, 1986).

The belief that nature is unfolding provides the basis for a paradigm. The paradigm is based on a belief that nature cannot be predicted, but that future states are shaped by 'creativity' (Jantsch, 1982). Creativity is found throughout the universe according to Jantsch.

Many other researchers have similar views: For example: Oates (1989) suggests that an analogous concept of 'information' is present throughout the universe; the physicist David Bohm postulates the concept of implicate order to describe how nature functions[27]; Rupert Sheldrake (1984) puts forward the hypothesis of formative causation to explain the way nature functions; Carl Jung, a psycho-analyst, believed all parts of the universe are connected by 'meaning' and Jung dismissed the concept of coincidence (randomness) (Jung, 1973); Prigogine sees order in 'chaos'; Capra (1983, p 292) sums up the shared insight:

> *"... individual minds are embedded in the larger minds of social and ecological systems, and these are integrated into the planetary mind of Gaia - which in turn must participate in some kind of cosmic mind."*

This view is profoundly different to the reductionist myth, which suggests that nature is nothing more than a machine.

4.3.5 How ecosystems function: Key Points

The following points provide a framework for understanding how an ecosystem functions.

- Ecosystems can be described in terms of patterns. 'Pattern' refers to the arrangement of parts and connections and can only be defined in qualitative terms.

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[27] Bohm's findings can be found in readable form in Capra (1983), Briggs and Peat (1984).

- Feedback loops are vital for maintaining an ecosystem's pattern. Adaptations to external changes may not become apparent quickly, due to long feedback response times.

- The concept of slow and fast variables is useful for understanding how ecosystems function.

- Ecosystems must be understood in terms of variations in quantities of materials, not just in terms of averages.

- Fluctuations, or events, play a pivotal role in determining the pattern in an ecosystem. Ecosystems are continuously adapting to fluctuations, thus ecosystems can be seen as unfolding as they move along the bifurcation tree.

- Ecosystem behaviour is not purely random (or probabilistic); it is chaotic and therefore indeterminate.

- Ecosystems are shaped by the creativity of nature. Creativity, or 'learning' may be present throughout the universe.

4.4 A Gaia-based view of ecosystem use

In this section the impacts human uses have on ecosystems is discussed using the concept of ecosystem pattern. Firstly, the concept of ecosystem complexity is introduced to describe patterns in ecosystems. The effects of human uses of ecosystems are then explained in terms of 'pattern', 'complexity', and 'risk'.

4.4.1 Complexity

An ecosystem's pattern can be qualitatively described in terms of complexity. Complexity is analogous to the concept of entropy reduction. A bifurcation is associated with a change in the level of complexity. For example, in the MacKenzie Basin wind erosion will create a 'simple' ecosystem (rocks) compared to the tussock-sheep system, however, if a wilding pine forest grows (a bifurcation) the level of complexity will be higher.

Human uses of ecosystems involve subtracting 'complexity' from the ecological system and adding it to the social system. The ecological system is moved to a lower level of complexity or is "run down" (Regier and Baskerville, 1986), the human system moves to a higher level. For example: human uses of the Great Lakes ecosystem have simplified the pattern in the Lake Ontario Fishery, and the ratio of small, less complex fish to large fish has increased dramatically (Figure 4.12), meanwhile human settlements around the Great Lakes have increased in complexity; Similarly, logging indigenous forest reduces the forest's complexity but results in an increase in the social system's complexity, signified by the development of towns and cities.

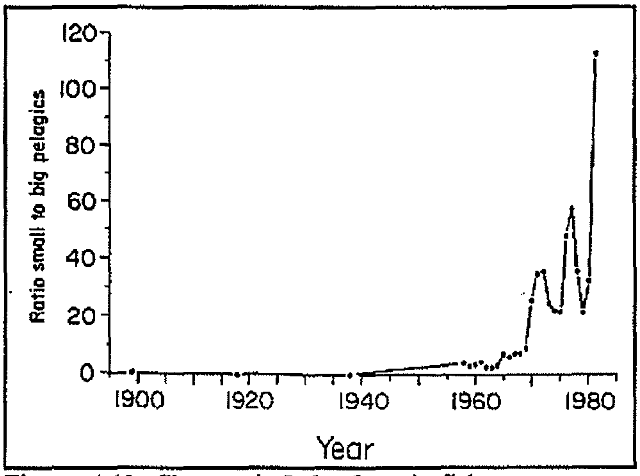


Figure 4.12: Changes in Lake Ontario fish communities. Small pelagics include smelts; big pelagics include pike and lake herring (Adapted from Keddy, 1991).

The concept of complexity can likened to the concept of 'capital'. Human uses of ecosystems use ecological capital. High complexity is like large amounts of capital, low complexity is like a small amount of capital.

4.4.2 Risk and risk paths

Bifurcations have two aspects; the occurrence of a fluctuation and the impact of the fluctuation. The combination of a probability of a fluctuation occurring and the effects of the fluctuation is termed 'risk' (Pyle and Gough, 1991). Thus, the relationship between social systems and ecological systems can be expressed using the concept of risk (Holling, 1986; Figure 4.13[28]). However, it should be noted that risk is used in a conceptual sense, not in terms of something that can be measured i.e. risk is meant in terms of 'surprise', or 'insecurity'.

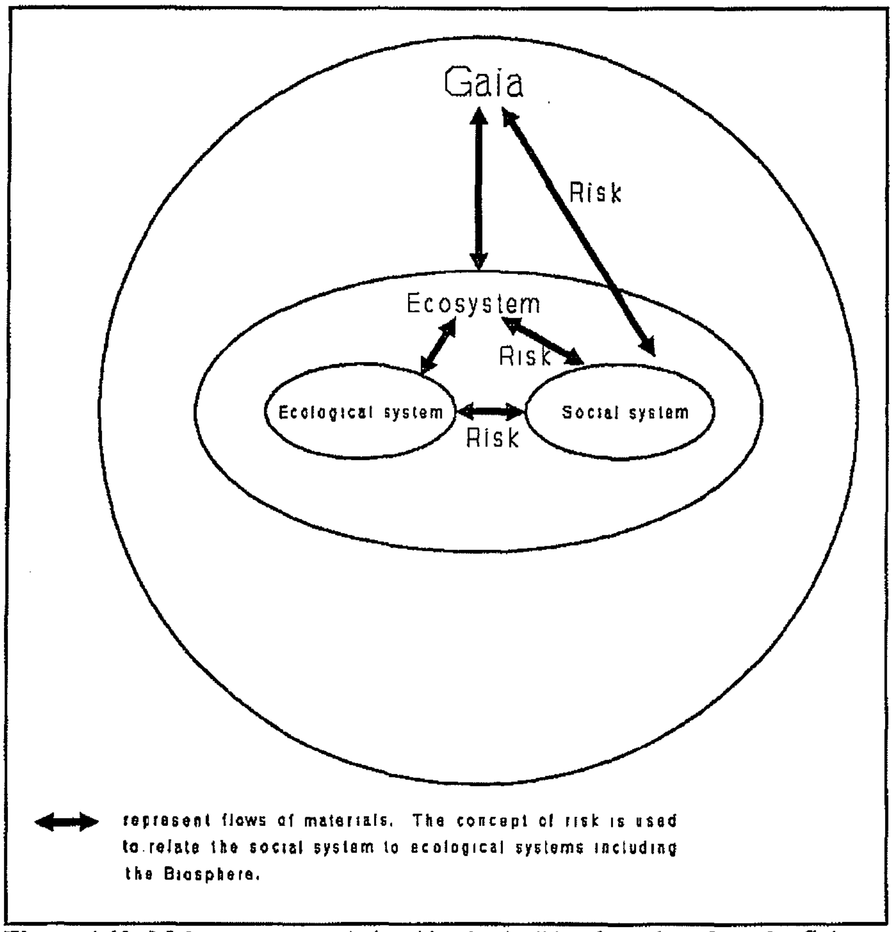


Figure 4.13: Major parts and relationships in the Biosphere, based on the Gaia hypothesis.

[28] This 'systems diagram' shows the relationship between humans and The Biosphere as it occurs at present. It is possible that the relationships could change (the modellers nightmare - Chapter Two). For example, humans could take over the ecological system, or the ecological system could 'throw the social system out', as some environmental 'dooms-dayers' are suggesting will happen (Ehrlich, 1991).

Humans can influence the risk they want to subject an ecosystem to. For example, the chance of a forest fire (caused by a fluctuation - a lighted match) occurring can be managed; in the MacKenzie Basin land management allowed a drought (fluctuation) to have a considerable effect. Patterns in ecosystems can be manipulated over time by managing the risks associated with ecosystem use (Figure 4.14). Thus, the concept of risk paths can be used to develop desired patterns in an ecosystem. Low risk-paths lead to increased complexity, high risk-paths lead to reduced complexity. For example, land management practices that take high climate-related risks, such as deforesting steep hill-sides, will inevitably cause resource degradation (reduction in complexity), such as accelerated soil erosion.

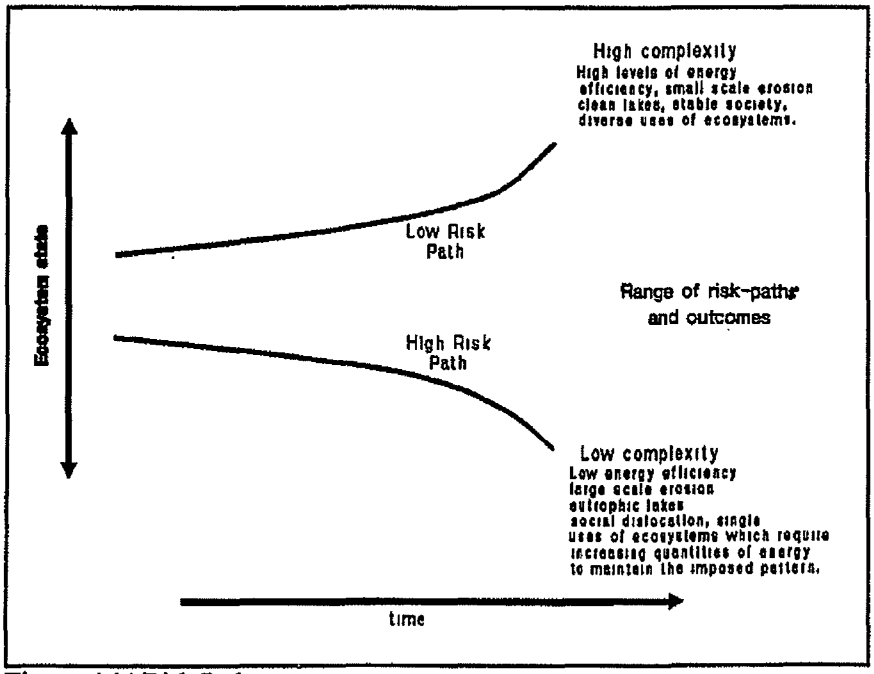


Figure 4.14 Risk Paths.

4.5 A Gaia-based view of 'sustainable' ecosystem use

In this section sustainable ecosystem use is defined. Ecosystem redevelopment is discussed as an integral part of the sustainability concept, then preventative and anticipatory aspects of sustainable management are outlined.

Sustainable use of ecosystems involves maintaining an ecosystem's pattern at a certain state, while recognising the interconnections between all ecosystems and the Biosphere. An ecosystem can have a range of patterns, such as farmland, native forest, indigenous forest, and there is not a 'correct' pattern for a particular ecosystem. The **desirable** pattern is a social choice but the range of options is constrained by biophysical features.

4.5.1 Ecosystem redevelopment

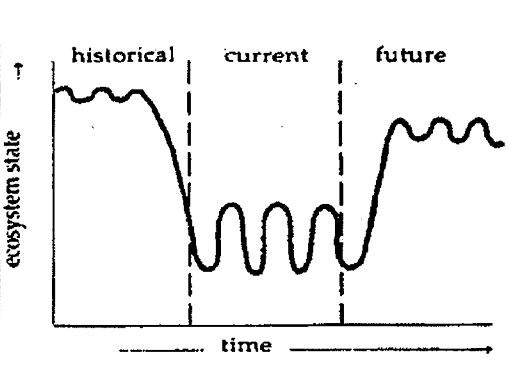
In the case of degraded ecosystems sustainable management means ecosystem redevelopment (Regier at al, 1989). There are two aspects to ecosystem redevelopment:

- changing the undesirable uses that caused the ecosystem to degrade and;
- changing the ecosystem structure.

Altering existing undesirable uses means changing the underlying cultural values and societal conditions which lead to the abuse occurring (Hartig and Vallentine 1989). Social systems must be redeveloped or 'learn' alongside ecological systems, otherwise ecosystem degradation will continue to happen.

An abused ecosystem may need an external force to shift it to a new state, because ecosystems contain an 'imprint' of past actions (Regier and Baskerville, 1986, Brinck et al, 1988) For example, ecosystems in some polluted lakes do not recover their original structure when the source of pollutants is removed (Björk, 1988). Sustainable management, therefore, includes the concept of **managed** ecosystem redevelopment.

Ecosystems can be redeveloped into a number of different patterns. The desired pattern is a social choice (Figure 4.14).



A hypothetical chronology of ecosystem status, from historical pristine conditions through current degraded conditions and ultimately remediation to a desired future state.

Figure 4.14: Ecosystem states over time (Hartig and Hartig 1990).

4.5.2 Risk reduction and risk avoidance

The concept of risk paths suggests that sustainable management is about avoiding high-risk activities. Risks can be reduced by using preventative and anticipatory approaches, and using the concept of 'baskets' of risk.

A preventative approach is concerned with limiting unexpected changes to an ecosystem by keying in on the use that causes the change, rather than the change itself (Simonis 1984). For example, a preventative approach to lake eutrophication would be to control landuse in the catchment, even when a eutrophication problem did not yet exist. This approach uses existing knowledge to assess the potential effects of human uses on an ecosystem. Managing human uses which have an unknown effect on the ecosystem requires an anticipatory approach.

The aim of an anticipatory (or precautionary) approach is to limit unexpected changes to the ecosystem's pattern even when prior evidence of change caused by a use has not been documented or 'proved' scientifically (Tait and Levidow, in press; Organization of African Unity, 1991). Anticipatory approaches have a practical orientation because there are no general principles that have application in every case (Scimemi, 1987). Specific anticipatory policies need to be developed for each situation involving human uses of ecosystems.

Anticipating risk at a strategic level in an ecosystem, such as national policy level, can lead to the avoidance of a whole 'basket' of risks throughout the ecosystem. For example, a national policy that discourages energy consumption and seeks to increase energy efficiency will reduce a number of risks, including: risks to rivers as a result of dam construction; risks associated with nuclear power; risks associated with greenhouse gas emissions; risks associated with relying on energy imports; financial and economic risks, such as costs associated with energy inefficient production systems.

4.6 A Gaia-based approach to sustainable management

In this section the key features of a Gaia-based approach to management are outlined. A Gaia-based management system consists of the following sequence of steps:

- developing a comprehensive picture of how the ecosystem is unfolding,
- gaining an appreciation of the problems that human uses have caused in terms of the ecosystem state or pattern. Identifying the desired pattern and implementing methodologies to achieve the pattern.
- monitoring how the ecosystem is unfolding and adapting management strategies.

There are two points that should be borne in mind when developing a management approach. Firstly, the Gaia-based cosmology suggests that management is a learning process, therefore the community must be involved in all aspects of management.

Secondly, the definition of the boundaries of an ecosystem should not be rigid. Ecosystems have permeable boundaries and therefore cannot be rigidly defined. It can be helpful to keep in mind the different levels of complexity in an ecosystem, from Gaia, to a region, to a catchment, to particular area (refer Figure 4.3).

The steps above are now outlined.

4.6.1 Understanding how the ecosystem has unfolded

The way an ecosystem has unfolded needs to be understood. The first task of management should be to establish a bifurcation diagram. The aim of a bifurcation diagram should be to develop a **comprehensive** picture of ecosystem development while at the same time being **comprehensible** to a community. The bifurcation diagram seeks to show the fluctuations that altered the ecosystem pattern, changes to the slow variables, and the state of the ecosystem over time.

Key indicators can be chosen to provide an assessment of other variables or processes that are difficult to measure, or for which there is no data available (McCracken et al, 1988). For example, the extent of forested riparian zones could be used to provide an assessment of the quantities of nutrients that reach streams from pastoral run-off[29].

Systems diagrams (Figures 4.16, 4.17) may be useful for describing how and why the slow variables changed in a clear and simple manner (McCracken et al, 1988). The diagrams need not be complex and can focus on the key relationships (Holling, 1978). Analysis of the relationships shown in the systems diagrams can provide an assessment of when and where the impacts of human actions can be expected. However, the static picture systems diagrams present can be misleading, thus systems diagrams have limitations as analysis tools.

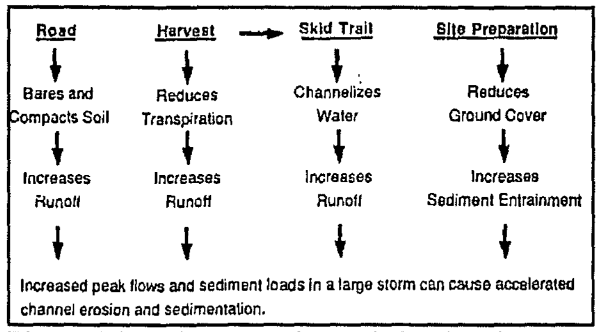


Figure 4.16 A 'systems diagram' showing the effects of logging on a stream channel (Cobourn, 1989).

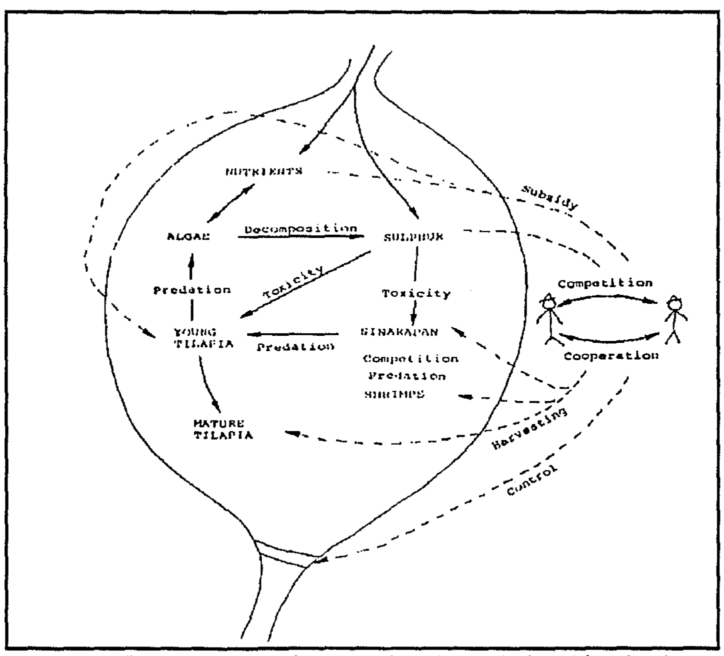


Figure 4.17: A systems diagram showing relationships in the Lake Buhi system, Philippines (Conway et al, 1989).

[29] Forested riparian zones are effective at filtering nutrients from run-off (Smith et al,1989).

Part of establishing the pattern in an ecosystem is establishing the social pattern. Through meeting with members of the community, key members of the community can be identified who can influence the community as a whole (McCracken et al, 1988). In open-systems terms, key people can act as deliberate 'fluctuations' and alter the pattern in a community.

4.6.2 Identifying the desired pattern and implementing management strategies

The choice of a desired pattern in an ecosystem is a social consideration but the range of options is constrained by ecological factors. This section outlines methods for choosing and developing a desired pattern.

4.6.2.1 Action Plans

A key aspect of choosing a vision is the idea of 'learning'. The community must participate in the decision-making process at a fundamental level so that they become part of the learning process and have a creative input into their ecosystem. 'Action plans' are successfully used in the Great Lakes to involve community in decision-making and have allowed the decision-making process to become a creative, learning experience for the participants [30].

An action plan is similar to the 'catchment management plans' that are in use throughout New Zealand. However, action plans are 'living' plans which have a high level of public input and are 'owned' by the public, whereas catchment management plans are produced by a management agency with a small amount of public input and the plan is 'owned' by the agency, not the public.

The action plan approach represents an evolution in the current style of catchment management plan used in New Zealand. Thus, the approach can be related to management in New Zealand and is therefore used in this thesis.

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[30] The description of action plans which follows has been synthesised from a number of sources. As a result individual references are difficult to cite. In this section and the following (4.6.2.2) references used include: Hartig and Thomas, 1988; Hartig and Vallentine, 1989; Hartig and Hartig, 1990; Great Lakes Water Quality Board, 1991; Hartig et al, 1991; Stage Two RAP Workshop Steering Committee, 1991; International Joint Commission, 1991.

4.6.2.2 Stakeholders' involvement, accountability and education

The key to developing and implementing an action plan is establishing a stakeholders' group. Members of the group should have a 'stake' in the area and be fully representative of community and national interests. In New Zealand stakeholders include 'green' groups, business, farmers, Maori, private individuals, Fish and Game Councils, Department of Conservation, Electricorp and others.

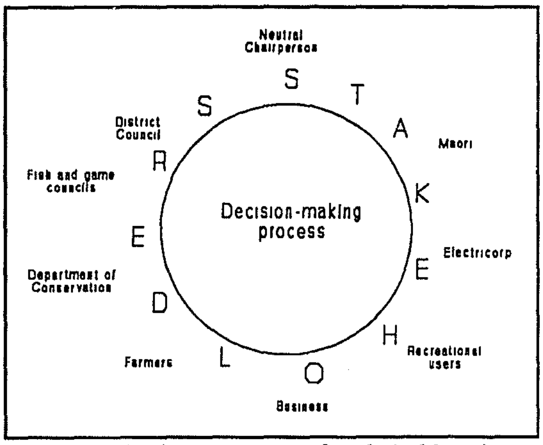

Figure 4.18: Arrangement of stakeholders in the decision-making process.

The stakeholders meet as equals in a 'round table' setting (Figure 4.18). Agencies with statutory responsibility for management coordinate the group of stakeholders. In New Zealand, Regional Councils would undertake this function under the Resource Management Act.

The stakeholders' group defines the desired pattern in the ecosystem; the 'vision'. The stakeholders develop the action plan, which identifies problems and methods for remedying them, the agencies responsible, and when the remedies will be implemented. The action plan becomes the means of achieving the vision. Through stakeholder involvement the community at large assumes ownership of the plan.

An independent higher authority audits the stakeholders findings (i.e. the action plan), checks the plan, for example, the higher authority checks that consensus on problem definition has been reached. Thus, accountability is introduced. Accountability, in this instance, implies responsibility and answerability.

Action plans should contain an educational component that reaches the whole community, not just the representatives involved in the decision-making process. Through education the community can be empowered to develop an environmental ethic which benefits their ecosystem, which includes themselves.

4.6.3 Monitoring

The process of monitoring involves feeding information back into the management system. There are two parts to monitoring:

- gathering information about the way the ecosystem is unfolding,
- using the information to adapt management strategies.

These two points are now discussed in general terms.

4.6.3.1 Gathering information

There is unlikely to be a single test which indicates the pattern of the ecosystem. A range of complimentary and coordinated approaches are necessary (Science Advisory Board, 1978; Hartig et al, 1990) and some general comments are now made about these.

"There is unlikely to be a single test which indicates the pattern of the ecosystem." (Cartoon adapted from Science Advisory Board, 1978)

The pattern in an ecosystem can be dependent upon the 'slow' variables. Both the state of the slow variables and the way they are functioning need to be simultaneously assessed. For example assessing changes to a forest's canopy (slow variable) would not detect the effects of deer and goat browsing of forest regeneration, while on the other hand monitoring the state of regeneration might provide little indication of possum browsing on the forest canopy. Thus, both the slow variables and the way they are functioning need to be assessed.

The size, frequency and timing of fluctuations can affect ecosystem pattern. Management systems can alter fluctuations, however changes to fluctuations cannot be determined accurately. For example, the effects that paving of land has on the size of flood peaks (fluctuations) in adjacent streams cannot be accurately assessed (Morisawa, 1985). Detecting changes in fluctuations will be difficult and the assessments unreliable.

Monitoring can use qualitative assessments including perceptions of ecosystem users. For example, a visual assessment of a catchment can indicate whether erosion is significant, fishers who keep accurate diaries might provide information about the fishery and the general condition of the aquatic ecosystem.

To assess pattern complexity, a variety of indicators need to be monitored and compared. A marked reduction in pattern complexity, such as a reduction in large species (Keddy, 1991), suggests ecological distress. Monitoring programmes may need to focus on the trends in 'indicator organisms' and identify useful indicators of ecosystem health that give warning long before effects are overtly detectable. The Great Lakes Science Advisory Board suggests that more research into establishing useful indicators is needed.

Indicators can also be used to monitor the amount of risk from particular sources. For example, in the Lake Tutira Catchment the Hawkes Bay Catchment Board (1988) monitors the number of stockyards[31] near to waterways to assess the potential impact on nutrients in the lake. The effect of risk reduction policies can be monitored by establishing whether the number of stockyards near to waterways is reducing.

4.6.3.2 Using monitoring information

Monitoring has a social aspect and should not be the exclusive realm of scientists and managers. Stakeholders should be involved in monitoring as part of the process of learning how their ecosystem functions. Monitoring programmes should assist communities in maintaining links with the ecosystem. Involving the community in monitoring might also be a useful educational exercise and might help communities to 'learn' about their ecosystem.

The users of an ecosystem should assess the monitoring results. People who use an ecosystem regularly will know how it is changing and will be able to compare the results of monitoring with their own perceptions. Involving local users in monitoring will help ensure that relevant information is collected.

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[31] Stockyards have been identified as a source of risk to the lake's eutrophic status (Hawkes Bay Regional Council, 1988).

4.6.4 A Gaia-based approach to sustainable management: Key Points

The overall point of the Gaia-based approach to management is the idea that the community learns as the ecosystem learns.

The key points of a Gaia-based approach to sustainable management include:

- the development of a bifurcation diagram,
- identification of the stakeholders and pinpointing the influential members and groups within the community,
- involvement of all stakeholders in decision-making in a 'round table' process,
- Involving stakeholders in monitoring and using key indicators.

4.7 The Gaia-based approach and the criteria for sustainability

In this section the Gaia-based approach is compared with the criteria for sustainable management (developed in Chapter Two) to assess of the sustainability of the approach.

The approach is compatible with the overall principle for sustainable management. The Gaia hypothesis implies that people are an integral part of ecosystems and depend on the Biosphere for their well being. The criteria for sustainable management are also met;

- **Integration of knowledge:** The bifurcation concept allows both qualitative and quantitative information to be used in the same framework. Education, or 'community learning' is an integral part of the Gaia-based approach.

- **Holistic perspective:** The Gaia hypothesis implies connectivity between all levels within the Biosphere and introduces an holistic perspective.

- **Ecological actions:** Connectivity and recycling are taken into account as a consequence of using the Gaia hypothesis.

- **Anticipatory and preventative actions:** Risk reduction and risk avoidance are seen as key features of sustainable management. Risk can be reduced by using preventative/anticipatory approaches, and using the concept of 'baskets of risk'.

- **Ethical actions:** This approach assumes that humans are an integral part of the Biosphere. Ecosystems are therefore viewed as being intrinsically valuable and a respect for nature is created.

Thus, the approach meets both the overall principle for sustainable management and the criteria. Methodologies based on this approach are more likely to produce sustainable outcomes, than reductionist approaches.

4.8 Summary

Using the Gaia hypothesis as a basis, the concept of sustainable management means sustaining certain patterns in nature, and communities learning as nature learns. The desired pattern in an ecosystem is a social choice but the range of options possible in any choice is constrained by ecological features.

Human uses of ecosystems tend to 'run-down' the ecological system. In cases where human uses have degraded the ecosystem pattern, sustainable management means ecosystem redevelopment. Redevelopment of degraded ecosystems requires simultaneous reorganization of the social and ecological systems.

The concept of risk can be used as a basis for developing management strategies. Community participation in management is crucial, because people need understand the risks their actions pose to their ecosystem which includes themselves. Action plans, which are formulated by stakeholder groups, are a practical way of implementing sustainable management and are well suited to management in New Zealand.

Chapter 5 Traditional Maori approach to management

"We [Maori] *have always been close to nature. In our use of it we give everything an aura. And this takes us into an awareness of environment and the need for conservation."* (Sinclair, 1975, p113)

"A combination of pragmatism and concepts concerning the environment provide the guidelines for resource management ... and sustainability is the overriding consideration." (Ngai Tahu, 1990, p3-2)

"Toitu te marae a Tane,
Toitu te marae a Tangaroa,
Toitu te Iwi."
(Whakatauki)

"Proper management of Tane's domain
and of Tangaroa's realm
ensures the survival of humanity"
(Proverb)

5.1 Introduction and chapter structure

This chapter aims to present the traditional Maori approach to management in a terminology that the western mind can cope with.

Western scientists and resource managers have difficulty coping with the reasoning and logic behind 'indigenous' management systems and consider these management systems to be based on 'ignorance' or 'myth' (Thrupp, 1989). Discussions I have had with New Zealand scientists and resource managers confirm Thrupp's observation.

Based on my discussions with western scientists, decision-makers and Maori, the difficulty westerners have coping with Maori approaches to management arises for two main reasons:

- Western scientists consider that Maori spirituality is metaphysical in nature and not 'scientific',
- The images presented by Maori are not understood by western scientists.

Through understanding the myth that Maori approaches to management are based on, western scientists can comprehend the Maori worldview and should be better placed to cope with Maori approaches to management.

This chapter firstly examines the likelihood that indigenous science can help to ensure **sustainable** outcomes from decisions. The use and extent of controls on human actions (management techniques) that arises from indigenous science is determined. Maori uses and abuses of ecosystems over the one thousand or so years of habitation in New Zealand are assessed in terms of sustainability.

The Maori approach to management is then outlined. Their view of the structure of nature, which is reflected in the cosmology and myths, is discussed. The approaches used to incorporate information into the management practices of Maori, including monitoring systems, are explained.

5.2 Sustainability and Maori approaches to resource management

It has been suggested that traditional Maori approaches to managing human uses of ecosystems are relevant to the concept of sustainability (Berkes and Farvor, 1989[32]; Easton, 1991, Anon., 1991, Ngai Tahu, 1990). This section investigates this suggestion.

When Maori arrived in New Zealand they brought with them knowledge of how tropical ecosystems functioned. Management practices that had been developed in tropical regions (such as swidden agriculture) were applied in New Zealand (Ngai Tahu, 1990).

Maori initially caused a significant amount of environmental damage in New Zealand before ecological limits became clear (Ritchie, undated). For example, Maori brought about the extinction of many bird species and destroyed much forest. As a consequence of resource depletion Maori were forced to adapt their management systems to the physical realities in New Zealand. Swidden-type agriculture became less important to Maori society and more direct uses of ecosystems, such as fishing and shellfish gathering, were developed (Ngai Tahu, 1990).

Eventually Maori developed a 'conservation ethic' (Patrick, 1987) and managed their uses of ecosystems sustainably using a complex and rigorous set of arrangements to control their use of ecosystems (Ngai Tahu, 1990, Easton, 1991, Waitangi Tribunal, 1991). For example, in Northland shark were only allowed to be fished on two days of the year (Easton, 1991); water use was controlled through a classification system (McCan and McCan, 1991); the lower Wairau River (near Blenheim) was physically modified to increase production of kai (O'Reagan, 1984). These arrangements consisted of a combination of pragmatism and observation of the way in which ecosystems functioned (Gray, 1991).

Evidence detailing the extensive knowledge Maori had of ecosystems and of the comprehensive nature of Maori tikanga (management arrangements or rules) has been presented elsewhere and will not be discussed further[33]. Suffice it to say that Maori had an extensive knowledge of ecosystems and had detailed and well developed systems of

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[32] Traditional approaches, as opposed to Maori approaches.

[33] Waitangi Tribunal Reports are an excellent source of this information.

management.

Thus, at the practical level, Maori approaches to management were sustainable. However, a sustainable approach was developed only when it became clear that ecological limits were being exceeded.

5.3 Cosmology

In chapter three it was argued that myth provides the basis for interpreting the way nature functions. In Maori society myths are derived from cosmology and the cosmology gives meaning to all aspects of Maori resource-management practices.

This section outlines traditional Maori cosmology. There are several versions of the stories that represent Maori cosmology but the essential ingredients are the same (Yoon, 1986).

In the beginning Io, the supreme being, existed alone in the world of Te Kore Kore (Marsden, 1975). Te Kore Kore is a 'void' and is the foundation of all things. Io dwelt alone in Te Kore Kore in a passive state. His thoughts were active. Thus, duality existed at the beginning.

Io's essence flowed forth to fertilize Te Kore Kore (Marsden, 1975) creating the world of Te Po. In Te Po the parts of the universe exist but they do not have any form. Te Po represents the state of becoming (Gray, 1991).

Io spoke and form was given to the major parts of the universe (Marsden 1975). Light entered into the world and place and structure were discovered (Gray, 1991). This state is 'Te Ao Marama', the state of being.

The Gods were next brought into being by Io. The first gods were Rangi-Awatea and Papa-tua-nuku. Awatea, the god of space and light, created the first heavens on the foundations laid by Io (Marsden, 1975). Rangi then looked down and saw Papa, descended and slept with her. Out of this union many offspring were born. These children, all male, were maintained in a perpetual state of darkness caught between Rangi and Papa who were locked in loving embrace.

This state of affairs angered some of the children. They resented living in a dark, cramped space. Io imbued the children with rebelliousness. Tane, the first born, forcibly separated his parents, having received the power from Io to perform this feat.

Io summoned Tane and commissioned him to continue creating the heavens, which he did (Marsden, 1975). The heavens were thus completed. Tane's brothers were delegated various tasks by Io who used Tane to convey his wishes. The brothers became 'regents' (appointed guardians or controllers) in the various departments of nature, such as the sea (Tangaroa), and were responsible for continuing the job of creation in these areas.

Tane and his brothers were descended from the 'Gods' and were therefore immortal. They were secondary beings referred to as 'atua' which carries the idea of a deity with 'power' (Irwin, 1984).

With the shape of the environment formed, Tane sought to create the female element (Irwin, 1984). In seeking the female element Tane produced trees, birds, insects but the female form eluded him (Irwin, 1984). Finally Tane went back to mother earth to obtain the life-giving essence (Gray and Saunders, 1990). The essence gives humans dominion in the natural, experienced world.

Tane breathed the Mauri-Ora (life principle), obtained from Io, into a female figure fashioned from clay. Woman entered the world. It is from the first woman (called Hine-ahu-one) and Tane that all human life descends.

Traditional Maori can cite their genealogy back through time to Tane and Hine-ahu-one, and ultimately Io. The 'spiritual' aspects of the universe are inextricably linked with life and living and cosmology forms the basis of Maori approaches to management. Humans are related to Tane, the other gods and at source are fashioned from the earth.

5.4 World-view

The Maori world view consists of three major parts, which represent being. The parts are symbolised by Te Kore Kore, the 'void' which is both active and passive and symbolises potential being, Te Po the world of becoming, and the world of being, Te Ao Marama which represents the world of light, purpose and structure (Figure 5.1).

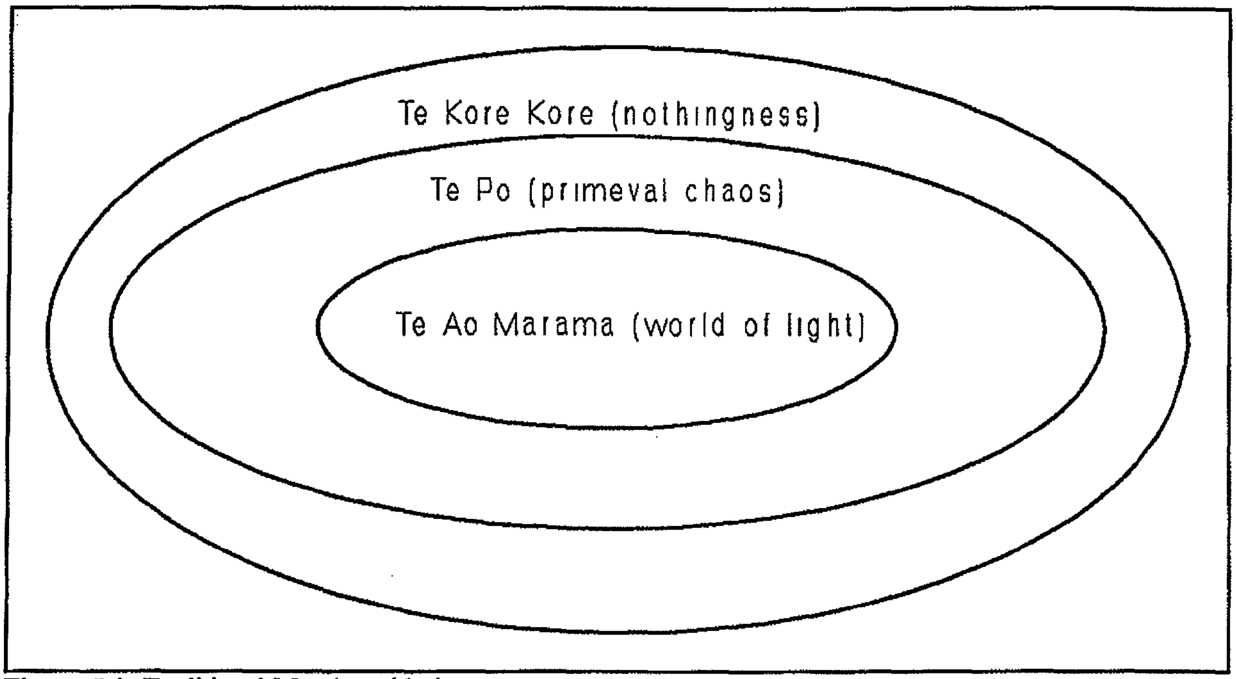

Figure 5.1: Traditional Maori world view.

Tane links the three realms and through Tane travel is possible in either direction. The spirits of the deceased leave the world of light descending to the world of becoming and that which is in the process of becoming (Marsden 1975). The energy of potential being enters the world of light from Te Kore Kore through Tane.

Marsden (1975) suggests that in the Po regions there is a fountain through which the primal energy of potential being travels from Te Kore Kore to Te Ao Marama. This 'stuff of Io' replenishes the essence in the world of light and creates what is new. Thus, the world is continuously being created and recreated, or the universe is continually 'unfolding'.

The Maori belief system suggests that the universe is not static but is a stream of processes and events. Each human is an event within the ongoing process of nature. The earth, represented by Papa-tua-nuku, is the 'rock foundation beyond expanse, the infinite', which suggests that the universe is a process or event within the cosmic process (Marsden, 1975).

All things are immersed in the cosmic process and given reality by the process. The cosmic process is ordered by Io. Thus, Io forms the ultimate reality, the expression of this is the cosmic process which exists in everything.

All things are immersed in the cosmic process and can be related by events only. Temporal scale is thus relative; all things occur in relation to one another and to the cosmic process as being within it. The situation is similar for spatial scale. But within this relative view of the universe there is an absolute view: From Io comes the order inherent in the universe.

5.5 Human's role in the worldview

A cornerstone of Maori social, physical and spiritual systems is the desire of people to gain mana (Saunders and Gray, 1990). Mana and the related concept of mauri linked[34] Maori to the worldview and cosmology, and provided the means for interpreting human's role in nature. This section outlines the place of mana and humans in the traditional Maori world view.

Mana is derived from the spiritual authority of the atuas[35] and embodies a range of western concepts, including prestige, authority, power (Marsden, 1975; Irwin, 1984). Atua are spiritual controllers of a resource and were part of the mauri associated with an ecosystem. The concepts embodied in 'mana' and 'mauri' are linked. To understand the concept of mana it is first necessary to outline the concept of mauri and the importance of mauri to Maori society.

5.5.1 Mauri

Mauri can be translated as 'life force' or 'elemental energy' and is attributed to an ecosystem, such as a forest or a river. The mauri associated with a part of an ecosystem was symbolised by an object (Best, 1942). The material mauri was usually a stone that acted as a shrine or abiding place of the atua. Dedicating an object as being representative of the mauri involved

[34] The past tense is mainly used because the traditional Maori approach is not in use in the decision-making process, as a consequence of mono-cultural legislation.

[35] Beings with divine status who had both metaphysical and physical attributes.

ritual (Best, 1924). The use of symbols provided Maori with a mechanism for interacting with the atuas and the metaphysical world.

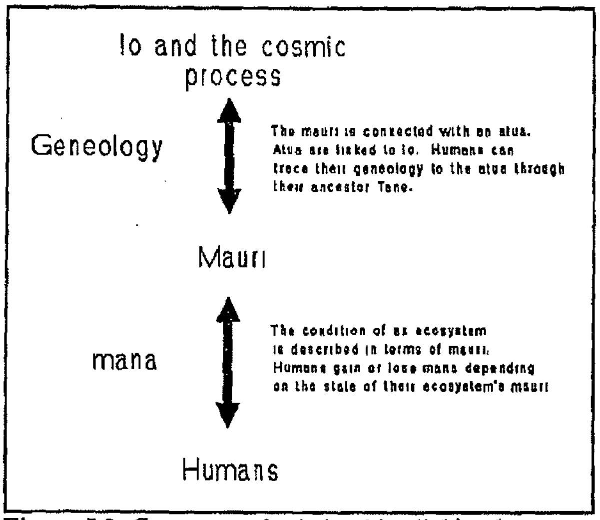

Figure 5.2: Concepts and relationships linking humans with the traditional Maori worldview

The concept of mauri relates ecosystems to the worldview through the concept of atuas or kaitiaki. An atua or kaitiaki (spiritual guardian) can tell Maori spiritual practitioners the condition or 'state' that the ecosystem is in and what uses of the ecosystem should be permitted (Gray, 1991). The atua is linked via genealogy to the original gods, Rangi and Papa, and ultimately the cosmic process. Thus, the concepts of mauri, atua and genealogy link Maori with their worldview and ultimately the cosmic process (Figure 5.2).

5.5.2 Mana

Human actions could enhance or reduce mauri. A reduction in mauri meant a reduction in the mana of the people who were associated with the mauri. The aim of Maori, therefore, was to protect and enhance the mauri associated with a resource. People's actions were therefore punished or rewarded in this lifetime through a reduction or enhancement of mana.

The concept of mana was collective to a community as well as being individual. A community would lose mana if the resources in their area diminished. For example, hosts who did not provide visitors with food specific to the region were considered to be lazy or they did not hold the visitors in high regard, either way they suffered a loss of mana (Gray, 1991); a failure to return a 'gift' of the 'regional delicacy' to another community would constitute a breach in the trading practices (Shortland 1856) reducing a community's mana. Thus, there was a need to protect the mauri at the community level, not just the individual level.

5.5.3 Risk management

In order to survive Maori had to use parts of the ecosystem. To gain mana the uses had to minimise risk to the mauri and ensure that the mana of the atua associated with a resource did not diminish for this would diminish the resource user's mana and reflect on the community.

Risk management formed the basis of the traditional Maori approach to the use of natural resources. The mauri associated with an ecosystem had to be subjected to an acceptable level of risk while allowing for a community's physical wellbeing. Those people or subsections of a tribe (Iwi) who were directly associated with a resource had the authority to make decisions about the acceptable level of risk (Gray and Saunders, 1990). The policy for resource use was set at a local level.

The structure of the management process was prescribed by spiritual protocols, peer pressure from the larger Maori society and spiritual practitioners (Tohunga). The marae formed the formal setting where issues of resource use were debated. A consensus approach was used; consensus (kotahitanga) was seen as a central value in Maori society and was seen as metaphysical in nature (Gray and Saunders 1990). Maori political process recognises the need to reach unity through consensus (Ritchie, undated). Policy-making thus involved the community at a fundamental level.

The community was an informed community, who had an intimate relationship with their ecosystem and relied on the ecosystem for their wellbeing. Young Maori were actively involved in tribal activities (Shortland, 1865) and learnt about their ecosystem in a 'hands on' way. Thus, through the educational process young Maori were introduced into management and the world view.

5.6 The world view in application

The world view was applied to management through the concept of Tikanga. This section outlines Tikanaga.

Tikanga represents the rules for controlling human uses of ecosystems i.e. rules to ensure that human uses expose the mauri to a minimum of risk. There are three parts to Tikanga (Gray and Saunders, 1990):

- scientific knowledge which relates to nature (Matauranga),
- cosmogenic information designed to benefit human kind, i.e. the anthropogenic mythologies (Whakaaro),
- rituals, acts which apply to all things on earth and the cosmos (Ritenga and Kawa).

The Tikanga (Figure 5.3) comprises complementary cosmological and physical dimensions. At the cosmological level spirituality (Wairuatanga) and the value of consensus (Kotahitanga) creates the notion of reciprocal caring within the community (manaakitanga) i.e. consensus and caring within the community have cosmological attributes. At the physical level, authority (rangatiratanga) is brought together with the concept of organisations (runanga) creating the social structure (whanaungatanga).

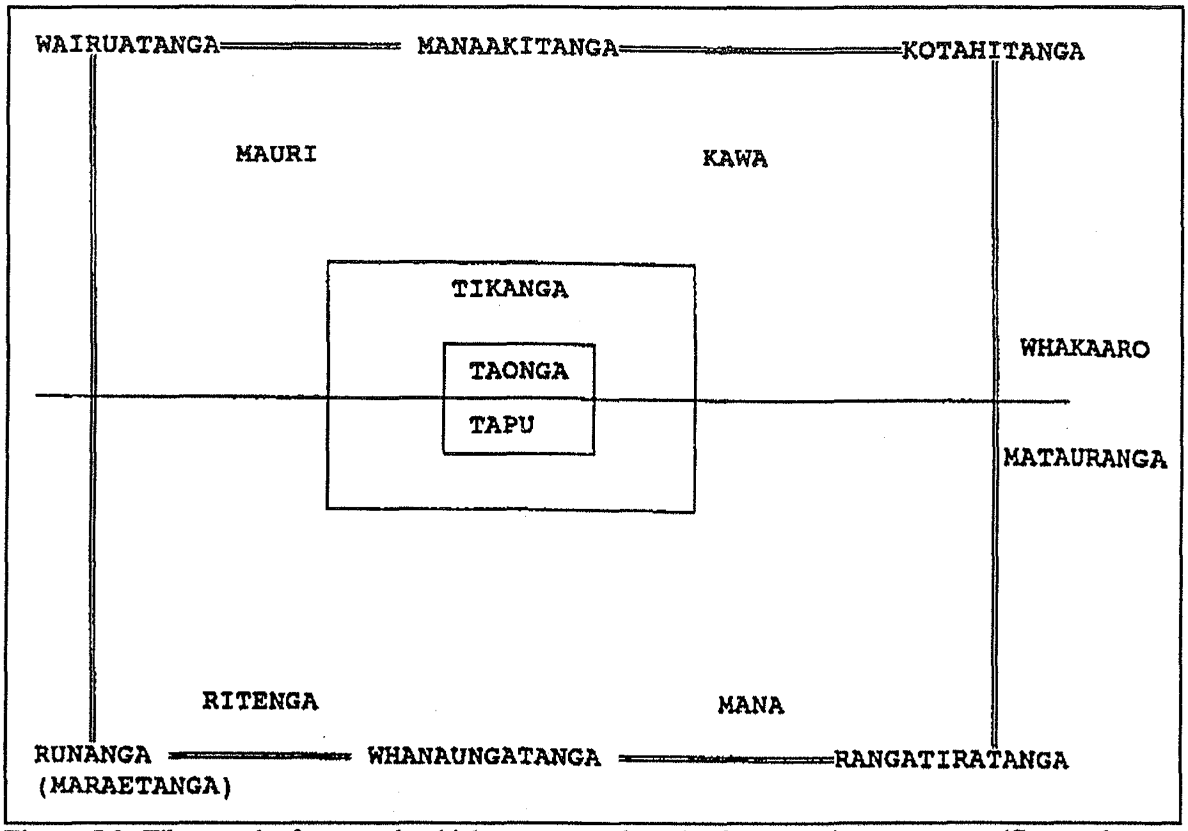

Figure 5.3: Tikanga, the framework which represents the rules for managing a resource (Gray and Saunders, in press).

Ritenga represents the way decisions are made and enacted, for examples the appropriate rituals to use. The concept of ritenga is associated with runanga or community and organization. Kawa represents collective decision-making, and is associated with kohitanga (consensus) (Gray and Saunders, 1990). As already discussed, mauri is connected with spirituality and mana is connected with prestige.

The concept of tapu was the primary ritual or institution used in the Tikanga system to protect a resource. Placing a tapu on a part of the ecosystem meant that the part was restricted for an atua's use. A temporary tapu, rahui, was implemented by a tohunga who had knowledge of the correct processes and rituals to use.

Monitoring was also part of the resource management framework, and provided information about the state of a resource's mauri. Gray (1991) suggests the Maori established direct contact with an atua to determine the condition of the mauri. Maori were also in touch with nature as a consequence of their hunter-gatherer lifestyle. They knew what was happening in the ecosystem of which they were part. Thus, monitoring may not have been something that consciously happened, Maori just 'knew' what the state of the ecosystem was.

The parts in the resource-management framework (Figure 5.3) are interlinked. For example; mauri is connected with mana; decision-making (ritenga) is connected with consensus and collective decision-making, which has metaphysical attributes; tapu is enacted at the physical level, but has metaphysical attributes also. Thus, there is a metaphysical\physical duality in the traditional Maori approach to resource management, and this point is crucial to understanding Maori resource-management practices i.e. traditional Maori resource-management had a strong religious flavour.

5.7 The Traditional Maori approach and the criteria for sustainability

The sustainability of the Maori approach is assessed in a comparison with the criteria for a sustainable approach (Chapter Two). This provides the theoretical assessment of the approach's sustainability and provides insight into how sustainability was achieved.

The overall principle of a sustainable approach, that people are part of their ecosystem, is met. Maori linked themselves with atua, who were guardians of ecosystems, through the concept of genealogy i.e. the atuas were Tane's relatives, and therefore relatives of humans also. With respect to the other criteria:

- **Integration of knowledge**: Through community-based decision-making that was resourced by experts the Maori approach could incorporate quantitative and qualitative knowledge. Information was disseminated to the whole community through the process of consensus decision making.

- **Holistic perspective:** An Iwi's mana was connected with a hapu's (group of families) and whanau's (family) mana. Thus, account was taken of regional and local actions.

- **Ecological actions:** Through their cosmology Maori appreciated the interconnections between all parts in the Biosphere.

- **Anticipatory and preventative actions:** Maori used the concept of risk to manage their use of ecosystems. Risk leads to concepts of prevention and anticipation.

- **Ethical actions:** Through the linkage between mauri and mana Maori society had an ecological ethic.

Thus the traditional Maori approach is compatible with the criteria for sustainability.

5.8 Summary

The concept of mauri gives meaning to Maori interactions with ecosystems. The mauri associated with a resource has a kaitiaki, guardian, called an atua. An atua is a 'deity' and is metaphysical in nature. Through an atua a resource was linked to the hierarchy of gods and ultimately Io, who orders the cosmic process which is inherent in everything.

Maori linked themselves to their ecosystem and the universe through their genealogy. Thus, they saw themselves as being inextricably linked with their ecosystem in both a physical and metaphysical way.

The traditional Maori approach to management has both metaphysical and physical aspects. The aim of traditional Maori management policies is to maintain and enhance an ecosystem's mauri. Thus, Maori used a process of risk management to ensure that mauri was sustained. A Maori community would gain mana if their resources were well managed i.e. mauri was sustained. The arrangement between humans and ecosystems is shown in Figure 5.4.

An entire Maori community would be involved in managing a resource and management decisions were made using a consensus approach. A community was resourced by experts who had specific knowledge. Involvement of the entire community led to community ownership of management policy.

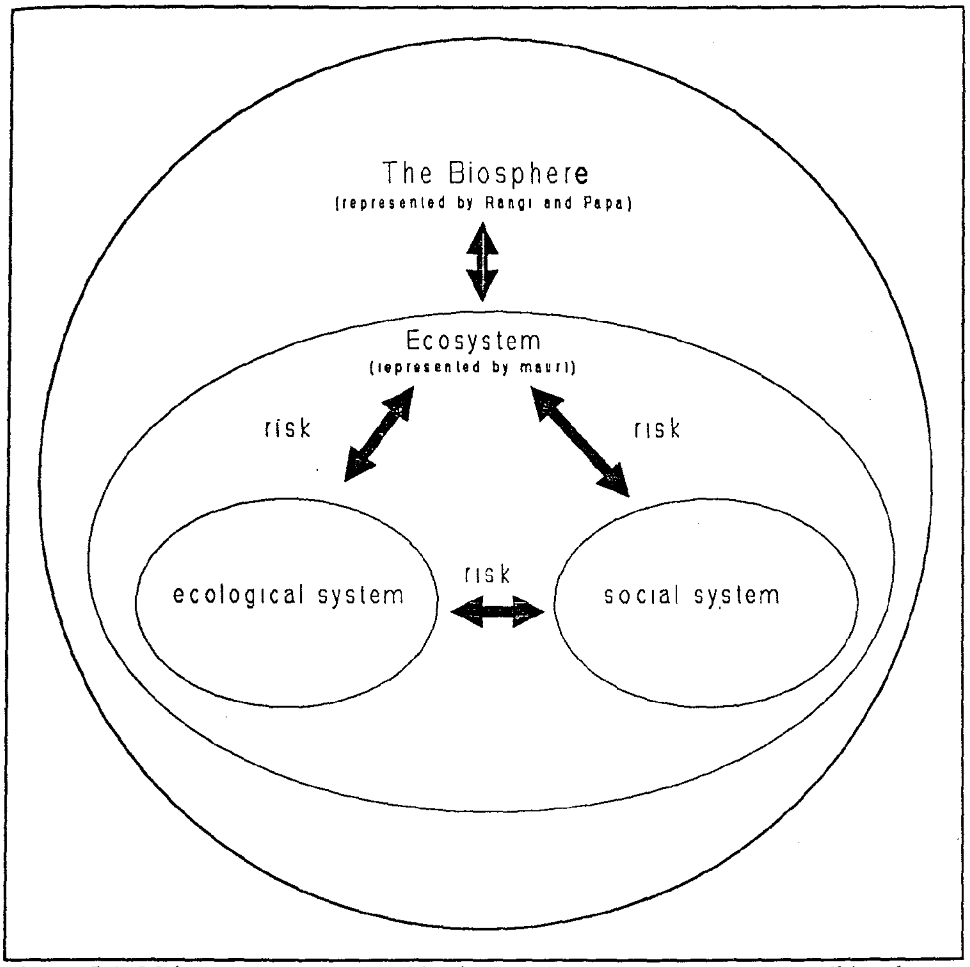

Figure 5.4: Major parts and relationships in the Biosphere, based on the traditional-Maori worldview.

Chapter 6 Unifying the Approaches

"There are few things more difficult than attempting to initiate a new order of things, partly because of the lack of responsibility and self-interest of the players in the drama, but also because of the incredulity of those who do not truly believe in anything new until they have had actual experience in it." (Read, 1989, p11, Quoted in Cameron and Elix, 1991, p 167)

"[To solve our environmental troubles] ... *we need new know knowledge, new perceptions, new attitudes ... We need nothing less than a basic reform in the way our society looks at problems and makes decisions"* (President Richard Nixon in a report to the Environmental Quality Council, 1970. Quoted in Oates, 1989, p14)

6.1 Introduction and chapter structure

An approach to sustainable management in New Zealand needs to consider both Maori and European values in the same framework. In this chapter a management approach is synthesised from the Gaia-based and traditional Maori approaches. Firstly, the traditional Maori and Gaia-based approaches are compared and contrasted. Secondly, an approach is outlined which incorporates key aspects of both approaches, called the 'unified' approach. Thirdly, obstacles to implementing the unified approach are outlined. Fourthly, the unified approach is briefly compared with the reductionist approach to management.

6.2 Comparisons and contrasts between the Gaia-based and traditional Maori approaches

In this section the Gaia-based and traditional-Maori approaches to management are compared and contrasted at the conceptual and practical levels.

6.2.1 Conceptual level

At the conceptual level the following points are used to compare and contrast the approaches.

- **Origins:** An 'origin' refers to the reasons why a management approach developed. For example, the Gaia-based approach developed out of the realization that the existing approach to management was not sustainable.

- **Cosmology:** Management approaches are formed on the basis of beliefs, or 'myths', about the way nature functions (Timmerman, 1986). Myths about nature stem from cosmology, for example, a cosmology that views nature as a machine (as reductionism does) will lead to myths like nature can be objectively observed.

- **View of the Biosphere and human relationship with the Biosphere:** Cosmology provides humans with a view of nature and provides an understanding of human relationships with nature. For example, Maori cosmology leads to humans having a genealogical connection with The Biosphere.

- **Concepts used to relate human actions to ecosystem outcomes:** Concepts and techniques for relating human actions to outcomes develop from myths. For example, the myth that nature can be objectively observed leads to the technique of predictive modelling.

- **The decision-making process, including monitoring outcomes:** The concepts and techniques used to relate actions to outcomes shape the decision-making process. For example, predictive quantitative modelling may lead to decision-making processes being based around numerical analysis and being controlled by technical experts.

The approaches are now compared.

Origin of the approaches:

The two approaches share similar origins. They both developed out of the realization that the existing approaches to management were not sustainable.

Cosmology:

Both cosmologies are based on the concept that nature is an unfolding dynamic process. Maori suggest that nature's evolution is shaped by Io's creative essence. The Gaia-based approach uses the concept of creativity to describe how nature evolves.

Views of the Biosphere, and human relationships with the Biosphere:

The two views of the Biosphere are similar. The image of 'Gaia' is similar to the image embodied in 'Papa-tua-nuku'. The traditional Maori system links humans with the Biosphere (and the universe) through their genealogy. While the Gaia concept does not imply heredity it does suggest that humans are inextricably linked with The Biosphere.

Both approaches use the concept of higher and lower levels in the Biosphere. Maori use genealogy to represent this concept, the Gaia based approach uses the concept of levels of complexity.

Yet, the two worldviews do have differences. For example, Maori connect themselves with metaphysical beings ('atua') in a metaphysical way, and have an extensive use of symbolism. This metaphysical dimension does not form part of the Gaia-based approach, but the approach does not dismiss the Maori view either. For example, Carl Jung has documented the metaphysical side of the western mind (Jung, 1963; Jung, 1964).

Concepts used to relate human actions to ecosystem outcomes:

Each approach uses the concept of risk (in a conceptual, not numerical sense) as a tool to relate human actions to ecosystem outcomes. In the traditional Maori approach human actions must not subject the mauri associated with a resource to excessive 'risk'. In the Gaia-based approach, human actions must not subject the ecosystems 'pattern' to excessive risk. Pattern, mauri and risk are concepts that are common to the two approaches.

The decision-making process, including monitoring outcomes:

In each approach an acceptable level of risk is viewed as a community's decision. Decision making is resourced by 'experts' who have specialized knowledge, e.g. scientists and tohunga. When the approaches are judged on a 'ladder of community participation' (Figure 6.1), they both rank between the same rungs (seven and eight), and thus have similar levels of community participation.

Rungs on the ladder of citizen participation	Nature of involvement	Degree of power sharing
1. Manipulation	Rubberstamp committees	
2. Therapy	Powerholders educate or cure citizens	Non-participation
3. Informing	Citizens' rights and options are identified	
4. Consultation	Citizens are heard but not necessarily heeded	Degrees of tokenism
5. Placation	Advice is received from citizens but not acted upon	
6. Partnership	Trade-offs are negotiated	
7. Delegated power	Citizens are given management power for selected or all parts of programmes	Degrees of citizen power
8. Citizen control		

Figure 6.1: Rungs on the ladder of citizen participation (Mitchell, 1989).

In both approaches a higher authority takes an interest in the actions of the community, introducing accountability. For example, an Iwi's mana is associated with a whanau's action; regional councils have statutory responsibility for a community-based 'action plan'.

The approaches to monitoring have similarities and differences. The Gaia based approach uses a combination of community-based and scientific monitoring which is similar to aspects of the Maori approach. However, Maori could communicate directly with atua to determine the state of an ecosystem's mauri, but this type of metaphysical ritual does not have an equivalent in the Gaia based approach.

Table 3.1 summarises the similarities and differences between the two approaches. The approaches are very similar.

Gaia based approach	Traditional Maori approach
The concept of an unfolding, creative universe	The concept of an unfolding, creative universe.
Gaia	Papatuanuku
Layered view of Biosphere, beginning with Gaia, and moving to lower levels of complexity.	Heredity linking humans with atua, Tane, Rangi and Papa, and Io. i.e. different levels.
Pattern in an ecosystem	Mauri associated with an ecosystem
management concerns risk to ecosystem pattern	Management concerns risk to mauri
stakeholders have responsibility for management, using a consensus approach	whanau has primary responsibility for management, consensus decision making
stakeholders are accountable to a higher authority	Iwi made whanau accountable
Experts used to advise stakeholders	Experts used to advise whanau
The educational process is a key part of informing the community. Community involvement in management.	Education of community and community involvement in management.
Monitoring: use peoples perceptions, scientific ritual.	Monitoring: use peoples perceptions, spiritual ritual.

Table 6.1: Commonalities between the traditional Maori and Gaia based approaches.

6.2.2 Practical level

At the practical level there are differences between the approaches. For example, the traditional Maori approach uses carvings to describe the way ecosystems have unfolded (Simmons, 1985), whereas the Gaia based approach uses bifurcation diagrams and diagrams showing different levels of complexity. These differences are a result of culture and history.

Culture or '*Weltanschauung*' influence the way people perceive problems and structure solutions (Davies and Ledington, 1982). *Weltanschauung* are a product of past events, in that we cannot escape the shadow our past throws (Jantsch, 1982). Different events have shaped

Maori and Western cultures, therefore the *Weltanschauungen* are different, and the application of similar cosmologies is different also (Figure 6.2).

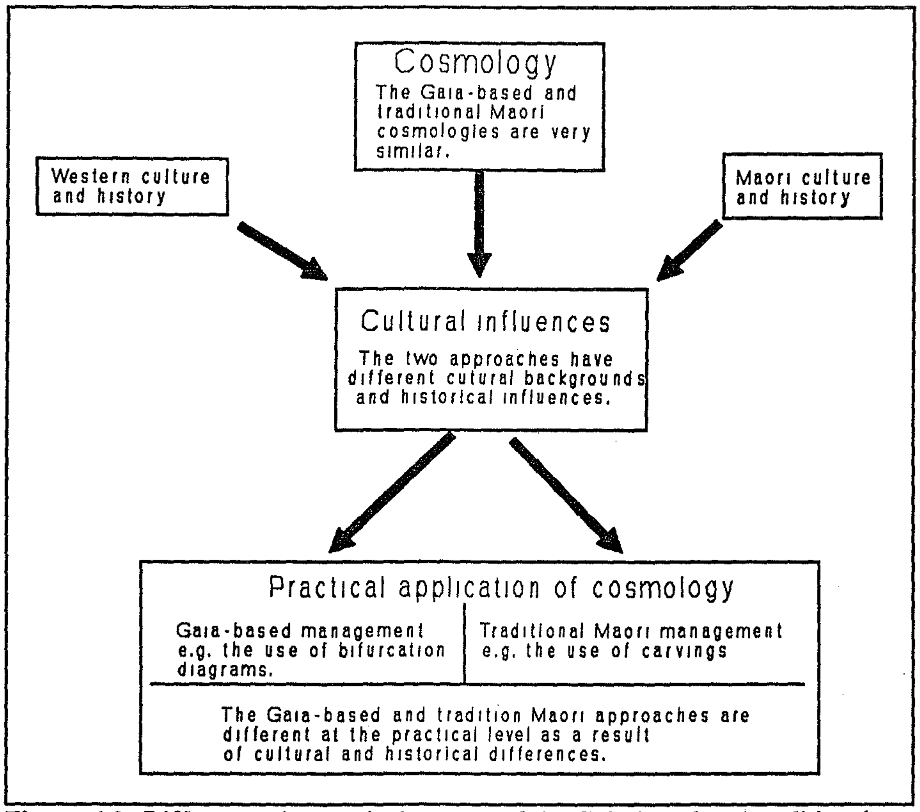

Figure 6.2: Differences in practical aspects of the Gaia based and traditional Maori approaches.

6.2.3 Comparisons and Contrasts: Key points

At the conceptual level there are many similarities between the two approaches, while at the practical level differences exist (Figure 6.3).

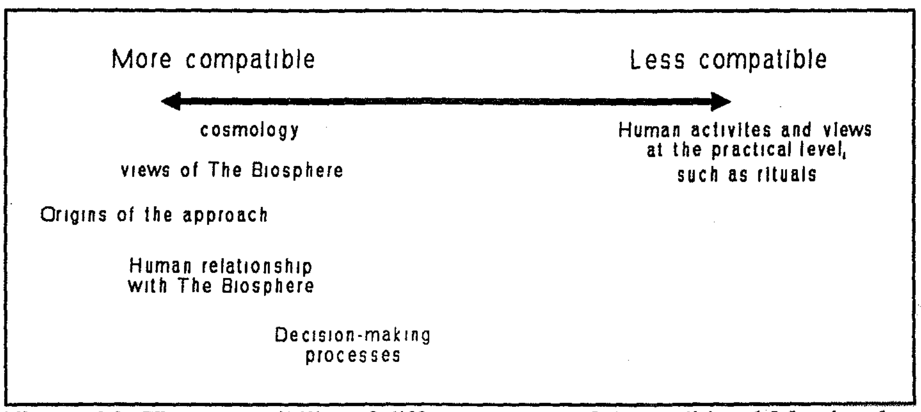

Figure 6.3: The compatibility of different aspects of the traditional Maori and Gaia-based approaches.

6.3 A unified approach

The traditional Maori and Gaia based approaches are very similar although some differences exist, particularly at the practical level. The key elements similar to both the traditional Maori and Gaia based approaches are:

- a view that the universe is unfolding in a creative, learning manner,
- concepts of pattern or mauri which are used to describe an ecosystem, with the concept of risk providing a means by which the impacts of human uses of an ecosystem can be understood,
- community involvement in decision-making using a consensus approach and including **all** stakeholders,
- an authority that has an overview, ensures accountability in the decision-making process, and provides the necessary expertise and persuasion, such as legislation,
- stakeholder involvement in implementing decisions and monitoring impacts on the ecosystem,
- education of both young and the community.

The above points form the basis of a 'unified' approach to management.

6.4 The unified approach and sustainable management

In this section the criteria established in Chapter 2 are used to assess the sustainability of the unified approach.

The unified approach views humans as being part of the Biosphere and is thus compatible with the overriding principle for sustainability. The criteria are also met:

- **Integration of knowledge:** The concept of risk allows different types of knowledge to be used in the same framework, including both quantitative and qualitative. The dissemination of knowledge, or 'community learning' is an integral part of the approach.

- **Holistic perspective:** The concepts of Gaia, Papa, mauri and pattern provide an holistic perspective. Different levels within an ecosystem are seen as being connected and part of The Biosphere.

- **Ecological actions:** The unified approach is based on images which suggest connectivity within and between ecosystems.

- **Anticipatory and preventative actions:** The concept of risk introduces proactive approaches.

- **Ethical Actions:** The unified approach recognises that all life-forms are important to maintaining mauri and patterns within ecosystems.

Thus, the unified approach to management is likely to result in sustainable outcomes.

6.5 Comparing the unified approach with the current (reductionist) approach

The aim of this section is to outline the differences between the unified and reductionist approaches. The approaches are compared using the points developed in Section 6.2.1.

Point for comparison	Reductionist approach	Unified approach
Origin of approach	Approach developed out of desire to predict positions of the planets and moon.	Approach developed out of the need to improve the sustainability of management.
Cosmology	Nature is a machine	Nature is an unfolding, learning and creative process.
View of Biosphere	Mechanistic, and a product of chance (Ho, 1988).	Gaia and Papa. A living entity.
Human relationship with The Biosphere	Separate from The Biosphere	Part of The Biosphere
Methods for relating actions to outcomes	Numerical analysis, systems models, reduce systems into parts.	Use of qualitative assessment and indicators. An awareness of the in accuracy of numerical analysis.
The decision-making process	Controlled by experts and exclusive of community	Managed by a neutral agent. Inclusive of community. Education of community an important aspect of decision-making.

Table 6.2: Comparing the reductionist and unified approaches.

6.6 Overcoming obstacles to implementing a unified approach

Many obstacles need to be overcome to implement a 'unified' approach[36]. This section outlines obstacles and methods to overcome these. An aim of this section is to demonstrate how the unified approach might be used in a practical sense.
The obstacles are grouped into categories. The first category discusses methods of overcoming obstacles in joining the two approaches. The remaining categories outline obstacles to implementing the unified approach, in terms of the steps in a management approach, which are:

- establishing how the ecosystem is unfolding,
- identifying the desired pattern and problem definition,
- implementing methodologies, community learning and monitoring.

In addition to the references cited in this section, information has been gathered from a number of sources including; through discussion with resource managers employed by Regional and District Councils, discussions with scientists, Maori representatives, and as a result of personal involvement in water resource issues[37].

6.6.1 Joining the approaches

Obstacle: Differences between the two approaches

At the practical level differences exist between the Gaia based and traditional Maori approaches. The dissimilarities stem from differences in the development of beliefs and practices and historical 'shaping factors'. Davies and Ledington (1988) suggest that ideological (cultural) differences in human activities can be solved creatively and through a learning process. Thus, communities need to 'learn' about themselves.

Yet, communities must want to learn. If a community does recognise a 'problem' and wants to do something about it, learning and creativity may be possible. Skilled facilitators may be required to help a community 'learn' about itself (Gaventa and Lewis, 1991).

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[36] These obstacles arise because the unified approach represents a new style of management; they are not a consequence of the minor differences between the traditional Maori and Gaia-based approaches.

[37] Specifically, minimum flows on the Wanganui River, Wanganui sewerage issue, setting a minimum flow for the Patea River.

Obstacle: Gaining Maori involvement in a stakeholder group

Maori have not been able to participate meaningfully in resource management decision-making for about one hundred and fifty years as a consequence of mono-cultural legislation (Minhinnick, 1984). During this time the practical aspects of their approach to management has not had the opportunity to evolve and adapt. In addition, traditional decision-making structures within tribes have been altered to meet European laws (Douglas 1984), which have failed to recognise traditional Maori organisations (Gray and Saunders in Press). Thus, Maoridom may have to redevelop practical aspects of their policy-making structure. Participants in the stakeholder groups can help overcome this obstacle by making Maori feel welcome and remembering that for the last one hundred and fifty years of resource management Maori have been 'out in the cold'.

6.6.2 Establishing how the ecosystem is unfolding

Obstacle: Difficulty obtaining accurate historical information

When developing a historical picture of an ecosystem it can be difficult to establish "Truths" (McCracken et al, 1988). Gaining many peoples' perspectives of historical issues can help establish a more accurate picture. Certain people in the community may have particularly relevant information, and these people need to be located (McCracken et al, 1988).

Obstacle: The propensity to call for further study resulting in inaction

Lack of information can stall decision-making processes. However, information now exists concerning the way different ecosystems function and this information needs to be applied to a specific situation. For example, it is now widely recognised that riparian zone management can improve water quality in streams and this knowledge can be applied to any stream ecosystem without detailed investigations (see Taranaki Catchment Board, 1989). In many cases detailed research will not be necessary and lack of information need not be a source of inaction.

Obstacle: Communication difficulties between experts and community

Managers, scientists and stakeholders have to communicate and achieve consensus on how the ecosystem is unfolded. Communication between experts and the public can be problematic (Timberlake, 1989). To overcome this obstacle Hartig et al (1991) suggest that scientists develop communication skills. Simple (but not simplistic) diagrams can be a useful method for conveying information (McCracken et al, 1988; Holling, 1978).

6.6.3 Defining the desired pattern and problem definition

Obstacle: Lack of agreement on problem definition.

Hartig et al (1991) report that problem definition by stakeholder groups has been inadequate in the Great Lakes. As a solution Hartig et al suggest that there must be detailed documentation and demonstration of how consensus on problem definition was reached. In New Zealand marae-based protocol, which has the principle of consensus as a cornerstone, may provide a practical avenue to achieving consensus and may allow a wide range of views of the 'problem' to be aired.

Obstacle: Difficulty forcing issues onto the political agenda

Legislation is needed that enables issues of resource use and abuse to be placed on the political agenda so that management agencies can initiate action (Bradsen, 1990; Elix and Cameron, 1991). The legislation should provide a framework for dealing with the complex issues concerning human uses of ecosystems (e.g. non-point source pollution). Legislation in New Zealand has been inadequate in this respect[38]. However, the Resource Management Act (1991) should enable complex issues to be tackled more effectively, by giving Regional Councils wider legal powers (Hutching, 1991).

Maori claims to the Waitangi Tribunal can force issues onto the political agenda. Many claims made by Maori are concerned with present unsustainable uses of ecosystems and the resulting loss of mahinga kai sources (e.g see Waitangi Tribunal, 1991). Recommendations made by the Waitangi Tribunal could be used to focus community attention on abuses of ecosystems.

In cases where human actions cause ecosystems to deteriorate slowly there may be difficulty in forcing the issue onto the agenda because a community does not perceive a problem to exist. In addition, scientific monitoring may have an insufficient length of record to assess changes in the ecosystem. This obstacle can be overcome by using historical information, such as knowledge held by old people, to qualitatively assess changes.

[38] For example, under the Water and Soil Conservation Act, 1967, resource managers found it difficult to control sources of pollutants that did not require a water right, such as pastoral run-off (Hutching, 1991).

6.6.4 Implementing methodologies, community learning, and monitoring

Obstacle: Difficulty in sustaining public interest and support

If the public does not see short term results they may lose interest in management of their ecosystem (Hartig et al, 1991). Coordinating educational activities and organising community activities are ways of encouraging and sustaining public interest. Stakeholder groups should set management goals, demonstrating local ownership of the management process, which will help sustain support (Hartig et al 1991). Key individuals are likely to have a role in maintaining public interest, by acting as leaders and organising activities in communities.

Agencies with statutory responsibility should manage, not control, stakeholder groups. A controlling approach sends a message to the public that they are not to have a meaningful role in management and will not encourage community interest in and support of ecosystem management (Stage 2 RAP Workshop Steering Committee, 1991).

Obstacle: Difficulty coordinating actions

Coordination is essential to achieving sustainable management because flows within ecosystems, such as water, cross many political boundaries, properties and areas of technical expertise. Perhaps of crucial importance is the coordination between stakeholder groups and local government. For example, The Great Lakes Water Quality Board (1991, p5) comments:

> *"Local governments can do much to help or hinder the* [community-based 'action plan'] *process."*

To ensure a consistent approach management agencies should work with stakeholder groups, and promote good communication with stakeholder groups.

Obstacle: Lack of long term planning

Gaining continuity in planning can be difficult. Planning often revolves around short term political cycles and budget priorities that can change annually. Hartig at al (1991) suggest that funding and resources for stakeholder initiatives. need to be planned for the long term, such as five years ahead, and initiatives that show commitment to long range planning should be financially rewarded by statutory authorities.

Hartig at al (1991) also suggest that sustained empowerment of local stakeholders will help ensure community enthusiasm and support over the long term and will encourage a long term view in the community. Osterman et al (1989) express this view also.

Obstacle: Unwillingness of individual stakeholders to adopt sustainable practices

In some cases stakeholders will have no incentive to change unsustainable uses of ecosystems. Statutory authorities have a role in providing incentives to stakeholders to develop more sustainable practices. At times legislation will be necessary and an essential aspect in forcing abusers of ecosystems to change their ways (Bradsen, 1990; Cameron and Elix, 1991).

Obstacle: Limited resources

Lack of resources, such as finance, is a traditional problem and in many cases is used as an excuse for inaction by management institutions. Finance can come from a number of different sources, including stiff fines for polluters, sponsorship by industry, grants from charitable trusts, rates, fund raising events. Ratepayers may be willing to pay for specific projects where environmental restoration is clearly needed or highly valued parts of ecosystems are threatened. For example, a survey[39] of ratepayers in Wanganui (1990) indicated a willingness to pay increased rates for improvements to the sewerage system.

Costs can be reduced by using volunteer labour. Volunteers can be a valuable source of willing and able workers, however, volunteers should not be abused and may need reimbursement for expenses. Hartig et al (1991) suggest that volunteers should be given a meaningful and productive roles in the management process.

Obstacle: Society's values being at odds with their actions

The International Joint Commission (1991) has observed that people want a clean environment but do not want to make the necessary adjustments to their lifestyles. This dichotomy creates an obstacle to implementing sustainable management. Environmental education is seen by the International Joint Commission as an essential tool to create an environmental ethic that prevents human abuse of ecosystems and engenders public support for actions which protect and enhance ecological systems.

Education of school children can be an effective way of educating the community, because children can take information home and influence their parents (Croft and Cole-Misch, 1991).

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[39] Commissioned by the Wanganui Waste Water Working Party and funded by the Wanganui District Council.

As Goldman (1991) stated:

"You get the children to tell their parents that they are destroying the environment."

6.6.5 Overcoming obstacles: Key points

The majority of obstacles that arise through implementing a unified approach are a consequences of a new 'ecosystem' style of management, as apposed to difficulties in joining the traditional Maori and Gaia based approaches. Research in many countries is showing ways of overcoming obstacles to implementing ecosystem approaches. Obstacles that arise as a consequence of differences between Western and Maori culture can be overcome if a community is prepared to 'learn' about itself.

6.7 Summary

The traditional Maori and Gaia based approaches are similar and can be combined into a unified approach which is compatible with the criteria for sustainable management. Many obstacles to implementing the 'unified approach' arise, but they arise not so much as a consequence of joining together two approaches, but arise because the unified approach represents a new style of management, compared with reductionist approaches.

The key features of a unified approach are:

- a view that the universe is unfolding in a creative, learning manner,
- concepts of pattern or mauri which are used to describe an ecosystem, with the concept of risk providing a means by which the impacts of human uses of an ecosystem can be understood,
- community involvement in decision-making using a consensus approach and including **all** stakeholders,
- an authority that has an overview, ensures accountability in the decision-making process, and provides the necessary expertise and persuasion, such as legislation,
- stakeholder involvement in implementing the decisions and monitoring impacts on the ecosystem,
- education of both young and the community.

Part Three

Applying the approach

Chapter 7 Sustainable management of Lake Forsyth

"*If a permanent outlet is provided ... the lake* [Forsyth] *will become a tourist attraction instead of a stinking green porridge as it is at the moment. There are very few lakes near a big city as Forsyth is, but look what we've let happen to it!*" (Barwick, 1971).

"*The lake itself* [Forsyth] *should be a valuable asset in the future if it can be cleared of pollution.*" (Suggate et al, 1978, p56)

"*... patterns can never be 'designed' or 'built' in one fell swoop - but patient piecemeal growth, designed in such a way that every individual act is always helping to create or generate* [desired] *patterns, slowly and surely, over the years make a community that has* [desired] *patterns in it.*" (Alexander et al, (1977), p xix)

7.1 Introduction: Problems with Lake Forsyth

This chapter seeks assess the workability of the unified approach. The unified approach is used to develop a management system for Lake Forsyth, which lies at the southern side of Banks Peninsula (Figure 7.1) and is separated from the sea by a shingle spit.

Human uses and abuses of the lake ecosystem has produced two readily identifiable problems which management agencies have had difficulty addressing. Firstly, the lake is extremely eutrophic. In most summers an algal bloom appears and fish kills have occurred. The algae contain a potent toxin and animals that drink the water have died. Management agencies have not established the causes of the eutrophication problem.

Secondly, human developments on the valley floor are flooded by either high lake levels, stream overflows, or a combination of both. The flood hazard posed by high lake levels is mitigated by breaching the shingle spit and releasing lake water to the sea.

The present institutional arrangements for the lake's management are complex. A Maori committee has responsibility for managing the water under the lake's surface; the Banks Peninsula District Council manages the surface of the water; farmers manage the lake margins; the Canterbury Regional Council has responsibility for water quality management.

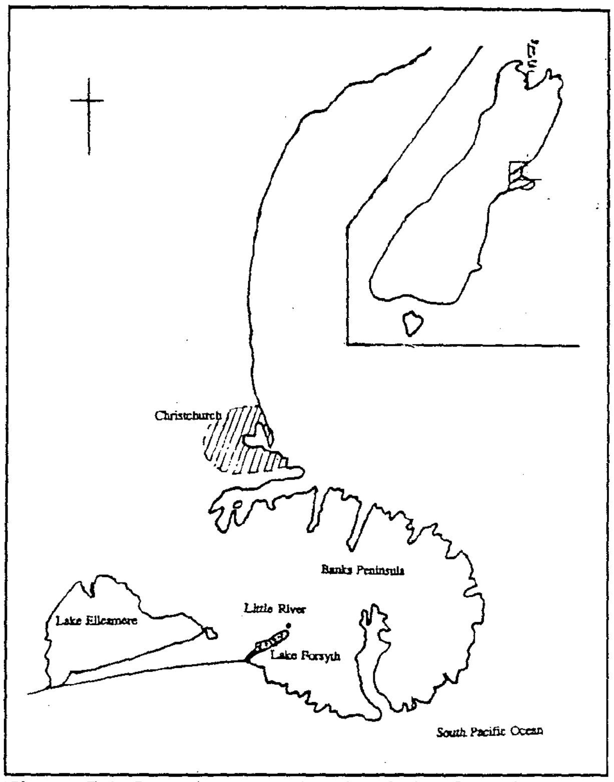

Figure 7.1: Location map showing Lake Forsyth

7.1.1 Methodology and chapter structure

The concept of an unfolding universe suggests that there are desirable and less desirable pathways that an ecosystem can take. To asses the workability of the unified approach a pathway (sustainable management strategy) is outlined for ecosystem development[1], but it is not the aim of this chapter to develop **definitive** solutions to the problems with Lake Forsyth[2].

The first stage of developing a 'pathway' is establishing how the ecosystem has unfolded. There are almost no scientific data for Lake Forsyth (e.g. see Livingstone et al, 1986). Records of lake levels were not kept until the 1950's, and have only been periodically kept since. Scant water quality data could be located. Hydrological records of stream-flows in

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[1] The application of the unified approach in this chapter reflects the author's background. The approach might be used differently by other people with different backgrounds and this may or may not influence aspects of the pathway.

[2] As a reductionist approach might.

the catchment are also patchy. Thus, qualitative assessments and indicators are used. Simple diagrams are then developed to explain the reasons for the lake's eutrophic state, the processes occurring at the opening point, and to outline how the ecosystem as a whole has unfolded.

The second stage is to define the desired pattern and identify the problems. The concepts of pattern, mauri and risk are used to defined the problems caused by human uses. A set of possible solutions to the problems are outlined.

Thirdly, the possibility for a community-based approach to management is assessed. It is not possible to say for certain whether the pathway suggested in this chapter will work in reality, for this would require the community to become directly involved as integral parts of the study, which is beyond the scope of the thesis. However, the approach has the slight merit of plausibility at least, and seems more applicable to the concept of sustainability than present conventional approaches, which have produced major problems in the Lake Forsyth ecosystem!

To facilitate the research for this thesis I lived in the catchment from Easter to November 1991. This enabled me to discuss management issues with locals in a relaxed and informal manner. Many of the people I had discussions with may not have been aware that their perceptions and values would be recorded. Therefore, I refer to people who provided me with information on an informal basis as 'locals', out of respect for their privacy.

Living near Lake Forsyth also gave me an opportunity to observe the ecological aspects of the area, such as wave climate, weather, colour and clarity of the lake. This information or 'local knowledge' has been invaluable for writing this chapter.

7.2 How the ecosystem has unfolded

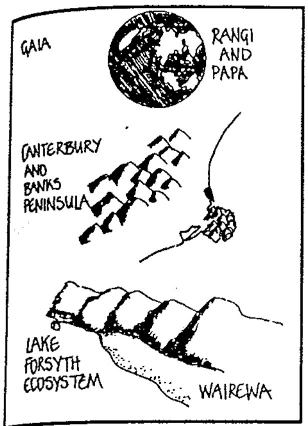

Figure 7.2: Different ecosystem levels

In this section the way the Lake Forsyth ecosystem has unfolded is described. When describing an *ecosystem* there needs to be an awareness of the connections with and between other ecosystems and between different levels of ecosystems (Figure 7.2). Description of the ecosystem begins at the level of Banks Peninsula, then the catchment, and the lake.

7.2.1 The Banks Peninsula

Lake Forsyth is an integral part of the Banks Peninsula. There are three parts to this section reflecting the changes ('bifurcations' in open-systems terminology) associated with the arrival of Polynesians and Europeans.

7.2.1.1 Prehuman history

Banks Peninsula was at one time an island volcano. Eruptions began about 12 million years ago and ceased about 6 million years ago (Weaver et al, 1985). Over the millennia valleys, which extend radially from the craters, were worn by streams and the cones became 'dissected' (Weaver et al, 1985). The volcanic rocks are fractured and have considerable water storage capacity. Numerous springs occur on the Peninsula maintaining stream flows during droughts (Sanders, 1985).

Dust and sand (loess) from glacial erosion in the southern alps has been blown onto the Peninsula by North Westerly winds. The loess mantle can be up to 20 metres thick and gives the hills a soft undulating form (Weaver, 1987). Glacial fed rivers flowing eastwards from the southern alps have carried large amounts of sediment towards the sea, forming the Canterbury Plains. At some time in the last 20,000 years Banks Island was joined with the Canterbury Plains (Weaver, 1987).

The Peninsula, being steep with high peaks, has plentiful rainfall, especially at higher altitudes. Soils on the Peninsula are fertile (loess and volcanic) and springs keep large areas of the Peninsula moist during dry spells. The first humans on the Peninsula would have found lush forest (Plate 7.1) and abundant wildlife.

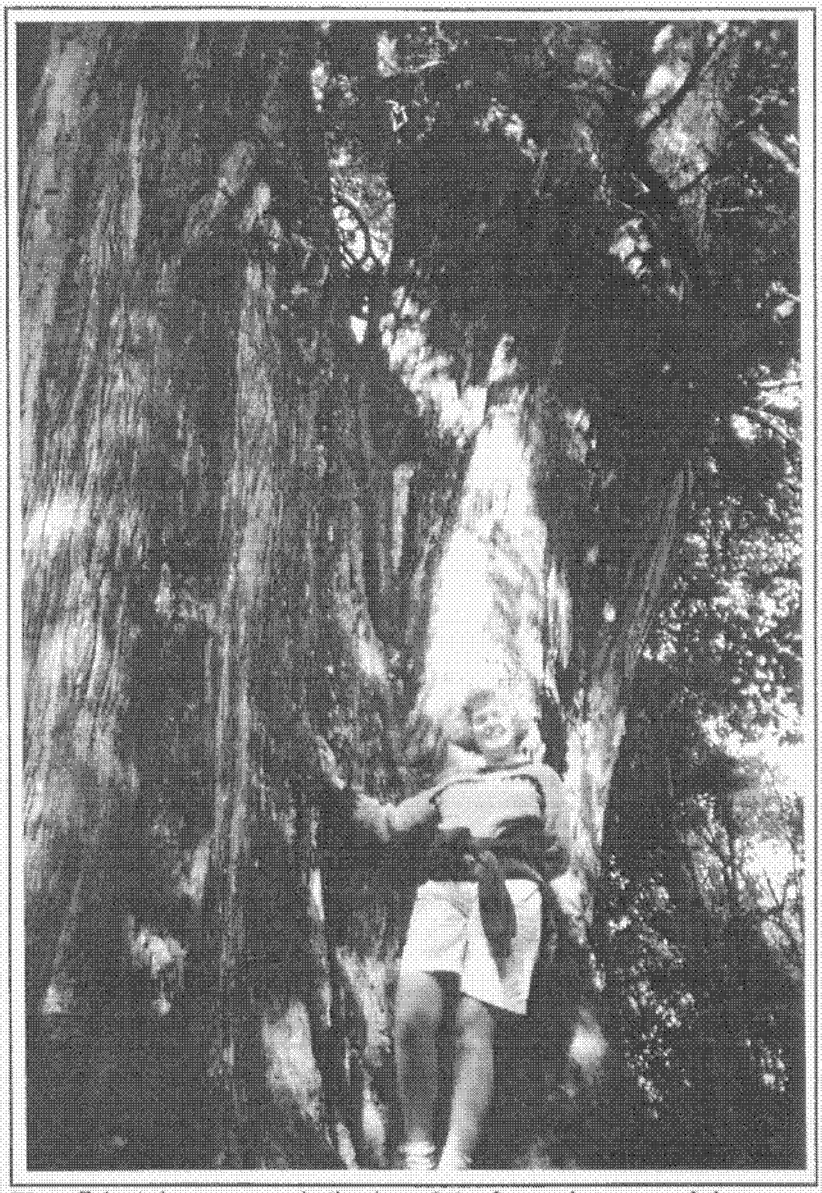

Plate 7.1: A large totara, indicative of the forest that covered the Peninsula.

7.2.1.2 Human history: Maori

Maori arrived on Banks Peninsula about 1000 years ago. The first inhabitants were hunter-gatherers. They lived off the abundant wildlife in the area, including seals, fish, shellfish and birds. Eventually many of the ground dwelling birds became extinct, such as moa. In addition, much of the forest was destroyed, reducing wildlife habitat and food resources. Populations of seals and shellfish also reduced through over-exploitation by Maori. Ultimately the Maori population declined as a consequence of resource depletion (McCullogh, 1987).

Humans thus degraded the ecosystem pattern in the Banks Peninsula, or reduced the ecosystems mauri (species became extinct, deforestation). The ecosystem pattern could no longer support the number of people or their style of living.

About 300 years ago Ngai Tahu moved into the South Island from the North Island. With the food resources now reduced (degraded ecosystem pattern) Maori adopted a more agricultural life-style, but still relied on hunting and gathering for survival. Spiritual practices became important as did family affiliations (Ogilvie, 1990). These cultural changes are likely to have evolved out of the need to develop good resource management practices (Gray, 1991) i.e. as a consequence of the way the ecosystem had adapted to human uses.

7.2.1.3 The arrival of Europeans

Sealers and whalers were the first Europeans to visit the Peninsula (1800's). From the 1830's onwards Europeans began to arrive in ever greater numbers. Demand for land grew and Ngai Tahu, who had become weakened by feuding and wars with Te Rauparaha, were robbed and cheated of their land (Ogilvie, 1990).

The Europeans quickly realized the value of the timber on Banks Peninsula. Numerous mills began operating. Between the 1860's and the turn of the century the Peninsula was virtually logged out (Pawson, 1987; Armstrong, 1962). Thus, Europeans significantly reduced ecological complexity or 'mauri', while social complexity increased; The Peninsula was denuded while the city of Christchurch took shape.

On the cleared land cocksfoot grass was grown from the early 1870's. The harvest of seed required much seasonal labour which could treble the Peninsula's population (Armstrong, 1962). Dairying and sheep farming also became widely established. The Peninsula became famous for its cheeses and was known nationally as 'cheese and cocksfoot country' (Pawson, 1987).

At around the turn of the century refrigerated transport became available, enabling farmers to sell both meat and wool on international markets (Jacobson, 19). This new opportunity stimulated sheep farming and dairying slowly declined. Sheep and beef farming are now the predominant land-uses on the Banks Peninsula.

7.2.2 The Lake Forsyth catchment

In ecological terms, and especially in terms of water flows, the Lake Forsyth ecosystem can be usefully defined in terms of catchment boundaries (Figure 7.3). In this section the geography of the catchment is outlined and human uses of the catchment are described.

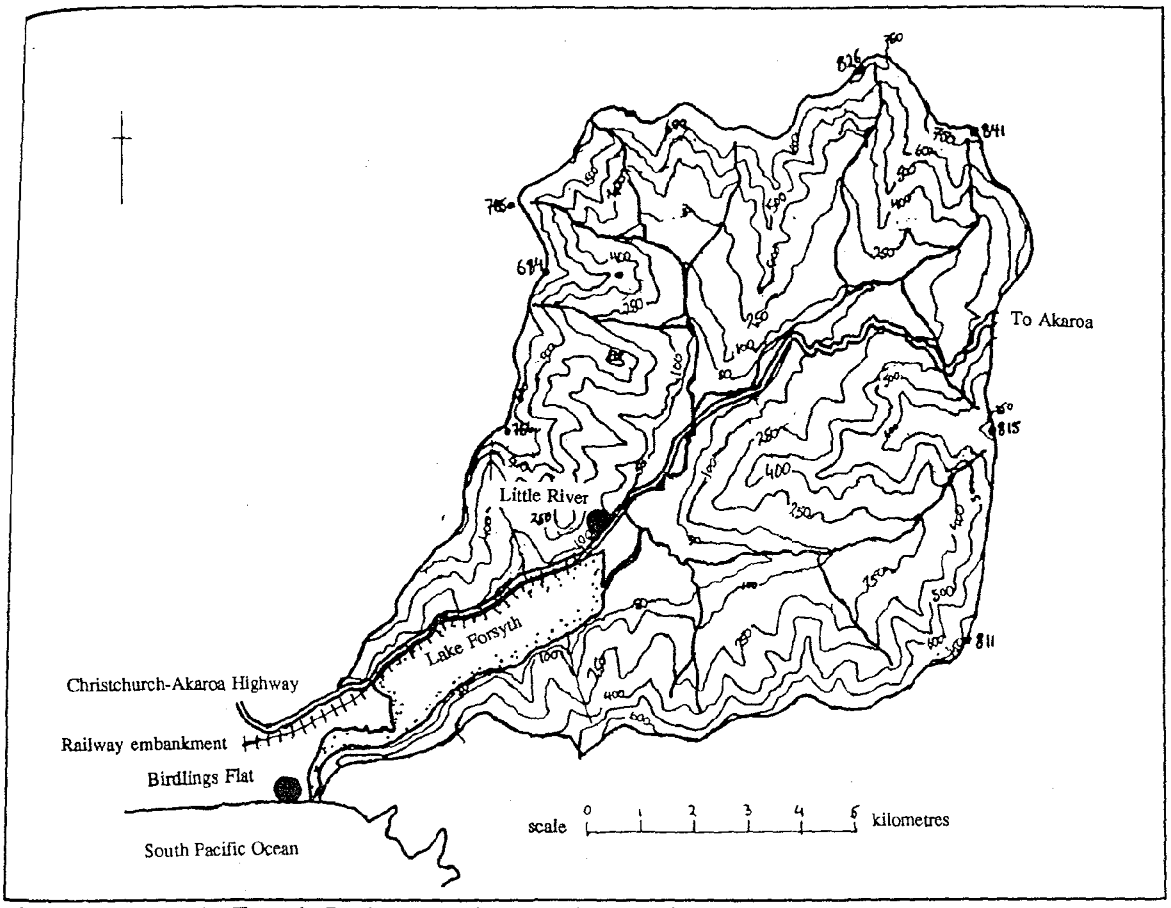

Figure 7.3 The Lake Forsyth Catchment (heights are in metres).

7.2.2.1 Geography

The catchment is roughly 110 km^2 in area (livingstone et al, 1986). The hills are steep and rise to over 800 m above sea level. The climate in the catchment is generally mild, but frosts are a frequent occurrence in the winter and snowfalls are not uncommon. At lower altitudes the snow does not remain long, but at higher altitudes snow may lie for several weeks, especially in shady places. Rainfall increases with altitude (Figure 7.4). Rainfall tends to be higher in the winter than in the summer (Cherry, 1988). Evapotranspiration can be greater than rainfall during the summer months and droughts occur occasionally (Flint, unpublished). Soils on the valley floor are especially fertile. However, at higher altitudes soils tend to become thinner and fertility declines (Flint, unpublished).

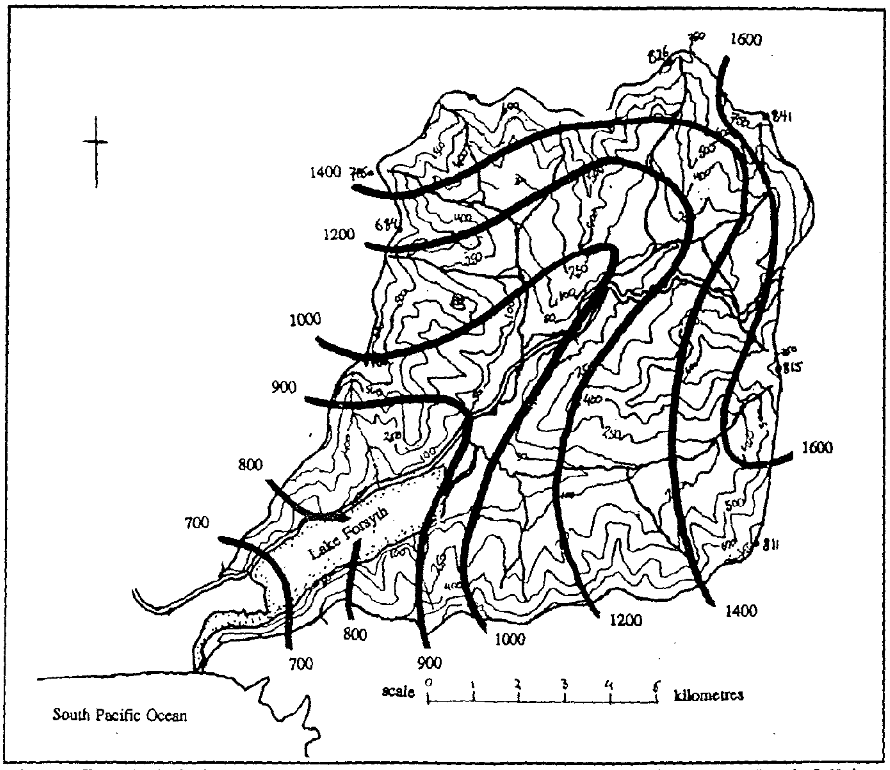

Figure 7.4: Rainfall map for the Lake Forsyth Catchment showing annual rainfall in mm (Adapted from Cherry, 1988).

The main catchment valley runs in a northeast to southwest direction. Northeast and southwest winds, both of which are common winds in Canterbury, tend to be funnelled through the valley. The Maori name for the Lake Forsyth area, Wairewa, may relate to the strong winds. Wairewa means 'water lifted up' and probably describes the way water is blown from the lake during windstorms (Nutira, 1991).

7.2.3.2 Human uses

The Lake Forsyth Catchment provided Maori with food such as eels, shellfish, birds, and other resources (Tikao, 1990). The early whalers were the first Europeans to realize the value of the timber resource in the catchment (Armstrong, 1962). Milling began in 1860 and by 1895 most of the millable timber was gone. The last mill closed in 1903 (Ogilvie, 1990). Timber was transported out of the catchment by punt across Lake Forsyth.

The township of Little River developed at the head of Lake Forsyth where goods were transferred from wagons to punts and in close proximity to timber mills operating on the valley floor (Ogilvie, 1990). A railway line linking Little River with Christchurch was completed in 1886 (Armstrong, 1962), which probably encouraged further development in the township. Early transportation patterns seem to have dictated the town's location.

The Catchment had its highest population ever recorded (414) in 1881 (Armstrong, 1962). The population in the catchment has slowly declined, to 317 in 1981 (Wairewa County Council, 1989).

Dairying became a prominent landuse in the Catchment following deforestation. A creamery was set up in Little River, the cream sent to Christchurch on the train, and the whey was fed to pigs, or discharged into streams. A dairy factory opened in the catchment in 1918 (Armstrong, 1962). Dairying has declined in the catchment (Table 7.1) in favour of sheep and beef production.

Year	Number of Dairy Farms
(around) 1920	20-30
1962	10
1991	3

Table 7.1: The number of dairy farms in the catchment (Source: Hutchinson, 1991; Armstrong, 1962; Fitje, 1991).

In the 1960's farmers were encouraged by the Ministry of Agriculture (MAF) to increase production by applying superphospate fertilizer (Armstrong, 1962). However, farmers in the Catchment were found to be conservative and were not prepared to apply much fertilizer, except on the fertile areas (Armstrong, 1962; Barrer and Stuart, 1960) Since the early 1960's fertilizer use in Wairewa County[3] has doubled (Table 7.2) but has declined in the late 1980's, according to locals.

Year	1962	1964	1966	1970	1978	1982
Tons of artificial fertilizer	525	603	1061	990	1041	704

Table 7.2: Quantity of artificial (Phosphate) fertilizer Used in Wairewa County: Source MAF farm statistics.

[3] Wairewa County incorporates The Lake Forsyth Catchment and neighbouring valleys, thus it is impossible to accurately estimate how much fertilizer was used in the Lake Forsyth catchment. However, the figures do provide an indication of the level of fertilizer use.

Weeds and scrub have encroached onto farmland in some areas. In places the scrub has regenerated into bush. Native species have regenerated particularly well along the banks of streams[4]. Wilson (1991) estimates that there is now ten times more native vegetation than at the turn of the century. The cover in the Catchment is shown in percentage terms in Figure 7.5.

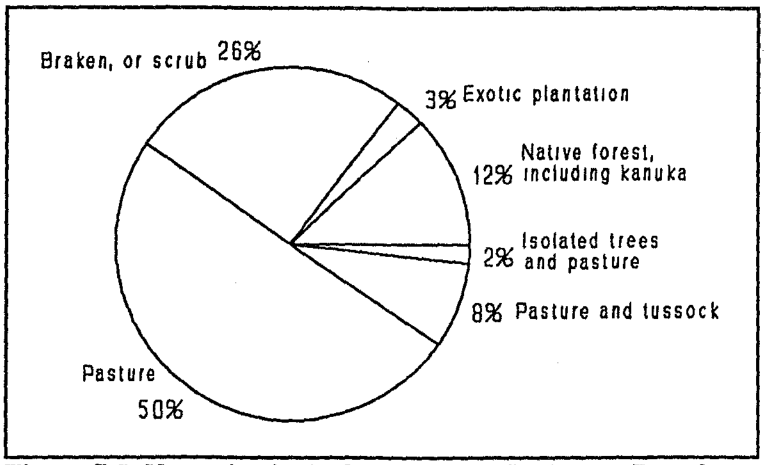

Figure 7.5: Vegetation in the Lake Forsyth Catchment (Data from Wilson, unpublished).

7.2.4 The Lake Itself

In this section the way the lake itself has unfolded is described. This section begins by outlining the physical aspects of the lake such as size and depth. Human uses are outlined, then discussion moves to the nuisance aspects of the lake, such as algal blooms.

7.2.4.1 Physical features

Lake Forsyth is rectangular in shape with a 'neck' that extends toward the sea. At its deepest point the lake has a depth of about 4 m at normal lake levels (Irwin, 1979). The lake becomes very shallow at the Little River end, where the lake margins are flat, low-lying (Plate 7.2) and often covered in water. The size of the lake varies considerably depending on water levels and wind conditions. When strong northeast winds coincide with low lake-levels large amounts of the bed are exposed at the Little River end and the lake covers a smaller area. Under normal conditions the lake is 4.5 km long, 1 km across and the neck is 2 km long.

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[4] Observed during numerous walks around the catchment during 1991.

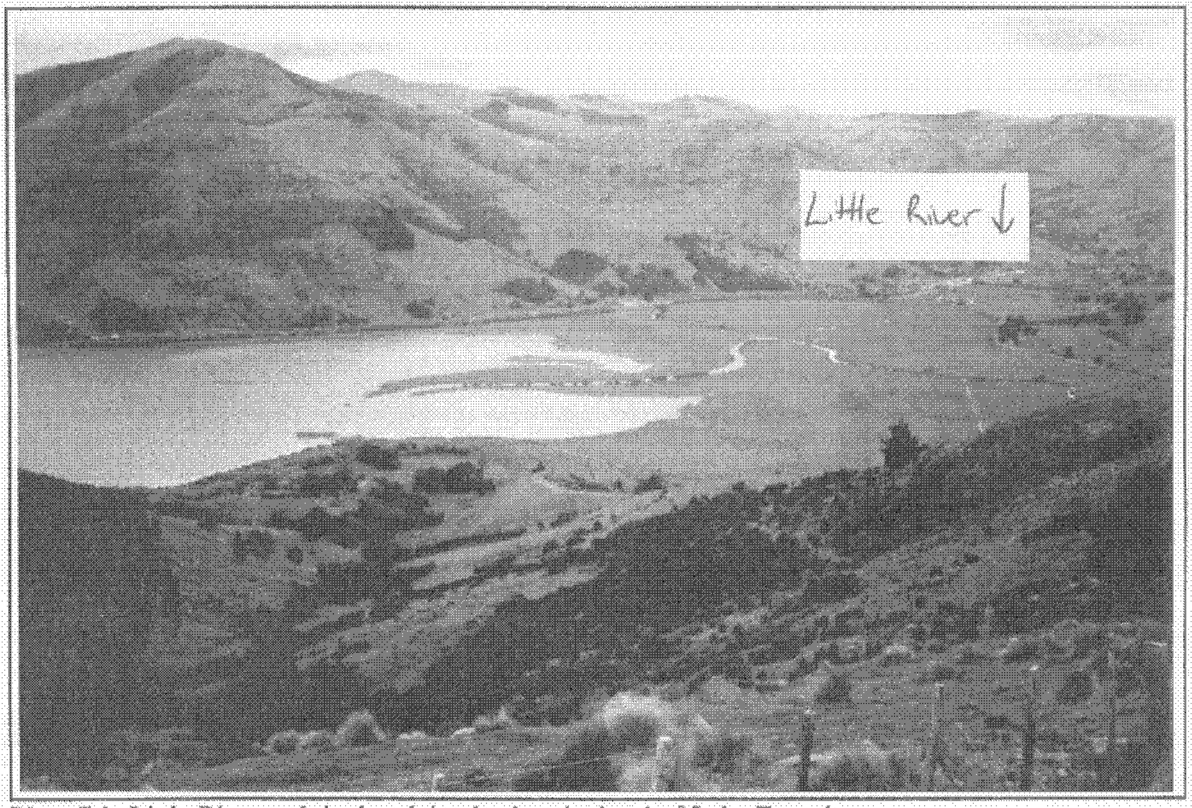

Plate 7.2: Little River and the low-lying land at the head of Lake Forsyth.

As a consequence of its shallowness and windy location muddy bottom sediments are frequently stirred up by wind-induced wave action. The colour and clarity of the water vary with wind conditions and the lake can change from looking 'clean' to turbid to 'clean' again within days. The water in the lake is probably well mixed.

The lake level varies between 0 and 5 m above sea level. Water leaves the lake via evaporation, seepage through the shingle spit[5], or via a lake opening. During wetter periods inflows exceed natural outflows and the lake level rises. Intense rainstorms can cause the lake to rise rapidly - up to 0.3m per hour (Flint unpublished). Lake levels fall rapidly when the lake is opened. When the lake is low, water levels vary with the tide, according to locals.

At times the lake-water is brackish. Salt water enters Lake Forsyth either over the shingle bar, through the bar or through a channel when the lake is open. The boundary between fresh and salt water can sometimes be clearly observed (Hutchinson, 1991).

[5] At times a 'plume' of dirty lake water is visible in the ocean adjacent to the opening point. At low tide water can be seen running from the shingle and into the sea.

7.2.4.2 Human uses

Lake Forsyth was and still is a valued source of kai to Ngai Tahu (Tikao, 1990; discussions with local Maori). Maori catch eel in the autumn on the lake-ward side of the shingle spit, as the eels attempt to migrate to the sea. Flounders are caught in abundance by both Maori and European.

Human uses of low-lying land adjacent to the lake and sometimes part of the lake have led to lake levels being controlled. The first recorded opening was in 1864 when the lake flooded the road along the lake's margins (Little River Roads Board minutes).

Over the years a number of recreational activities have taken place on the lake, including fishing (trout and perch), sailing, game-bird shooting, power boating, and rowing (Banks Peninsula District Council[6] files). Many of the users said that the poor quality of the water and associated occurrences, such as weed growths, algal blooms and foul odours, detracted from the lake's appeal as a recreation venue.

7.2.4.3 Weed, algae, flies and smells

Weed-growths, algal blooms, lake-flies, and offensive smells have been a nuisance to lake users and nearby residents since late last century. These issues are now briefly outlined.

Weed-growths were mentioned in press reports of rowing regattas as early as 1887 (Lyttleton Times 4-2-1887). In 1891 weed growths were so severe that they obstructed rowers (Lyttleton Times 18-2-1891) and weed-growths have occurred periodically until the present time, according to locals. The weed has a similar appearance to grass. Locals commented that at times Lake Forsyth looks like a hay paddock.

An **algal bloom** was reported as early as 1907 (Flint, unpublished). The water was a "hideous dirty green" and hundreds of eels and trout lay dying on the lake shore (Lyttleton Times, 14:1:1907, 30:1:1907). Algal blooms may have occurred prior to 1907:

> " ... *it was not unusual ... for the combination of dirty water and its temperature to kill fish.*" (Lyttleton Times 30:1:1907).

[6] Wairewa County Council, prior to 1989.

The algal bloom has been identified as *nodularia spumigena* (Flint unpublished). Nodularia requires nutrient rich brackish water, but growth rates are not dependent on nitrate enrichment because the algae fix nitrogen from the atmosphere (Öström, 1976). The algae produce a toxin. On numerous occasions stock and dogs have been killed by contact with the water (Wairewa County Council files).

Lake flies have been a problem at various times over the years (Wairewa County Council minutes, 5:4:68). The flies are most abundant in spring time. Locals remember the problem being particularly bad in the 1960's and lake-fly numbers appear to be reducing over time. However, the lake flies are still a nuisance.

At times the lake **smells** "like hell" (Hutchinson, 1991). On occasions the stench has made Little River almost uninhabitable (Ogilvie, 1990). Some locals suggest that the smells are related to the dying off of the grass-like weed, because when the decaying weed is removed from the water it stinks. Others suggest that whenever the lake gets low and becomes warm the smells occur.

7.3 Nutrients

The excessive weed growths, lake flies, algal blooms and smells suggest that Lake Forsyth is highly eutrophic. Eutrophication is associated with nutrient enrichment of a lake's water (Vant, 1987). In this section a nutrient model is developed to show the inputs of nutrients into the lake water.

Nutrients can enter lake water via stream inputs, seepage and re-suspension (Figure 7.6). The contribution from these individual sources is now outlined. There is very little data on nutrient flows in the catchment, therefore qualitative assessments and indicators of nutrients will be used to determine nutrient contributions.

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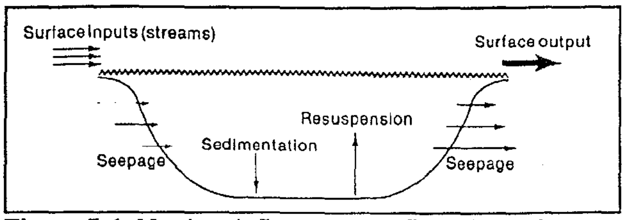

Figure 7.6: Nutrient inflows and outflows in a lake (Brock, 1985).

7.3.1 Nutrient inputs into streams

The following human activities affect nutrient levels in streams; dairy farming, fertilizer run-off, pastoral run-off and riparian zone management, deforestation, sheep farming, and sewerage. These points are now discussed.

Dairying farming

Methods for disposing of dairy effluent late last century and early this century are not well documented. Hutchinson (1991) suggests that effluent was discharged straight into creeks. Nutira (1991) remembers streams running white with whey in 1940's. Locals remember the stream below the dairy factory being full of algae and slime, which suggests that the dairy factory discharged directly into the stream also. It seems likely that large quantities of nutrients have entered the streams from dairying activities. The three remaining dairy farms in the catchment have effluent treatment facilities. The effluent currently reaching streams is thought to be negligible (Fitje, 1991).

Fertilizer and pastoral run-off, and riparian zones

Run-off from farmland can be high in nutrients due to fertilizer application and animal excretions (Haore, 1982; McColl and Ward, 1987; Ward et al, 1989). Nutrient levels in streams depend on a number of factors, such fertilizer application techniques, and vegetation in the riparian zone (Ward et al, 1989; Smith et al, 1989).

Fertilizer application in the catchment has never been high according to locals. Figures available for the Wairewa County (Table 7.3) and research by MAF (Barrer and Stuart, 1962) support the local opinion. Since the mid to late 1980's nutrient inputs from fertilizer would be very small.

Riparian forest can dramatically reduce the level of nutrients in pastoral run-off (Lowrance et al, 1985; Smith et al, 1989). A large percentage of riparian zones in the Catchment are forested (Figure 7.7; Plate 7.3). However, forested riparian zones on the valley floor are almost non-existent (Figure 7.7; Plate 7.4).

The large amount of forested riparian zone suggests that small quantities of nutrients are entering the stream from pastoral run-off in most of the catchment. However, significant quantities of nutrients may be entering streams in the fertile valley floor area, where riparian zones are not forested, farming is intensive, and fertilizer application may have been high.

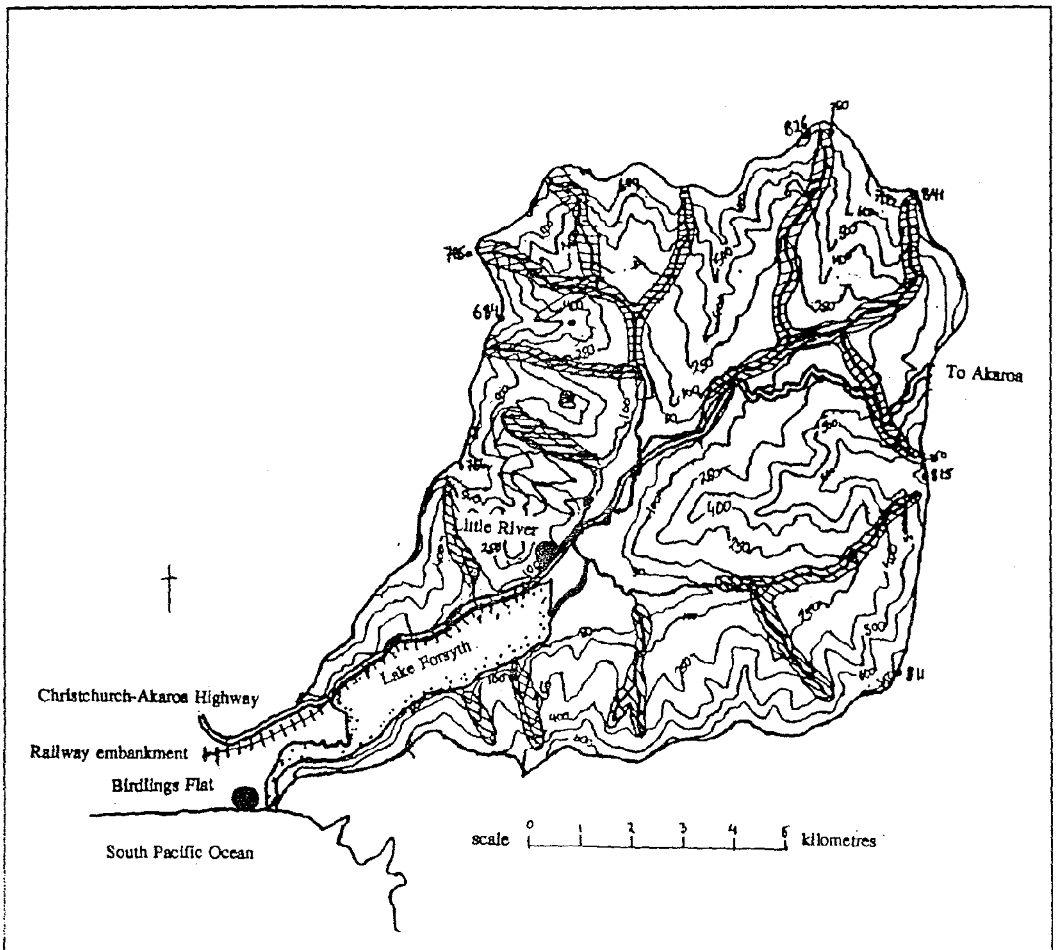

Figure 7.7: Forested riparian zones (source: aerial photographs taken in 1984, and observations in the catchment).

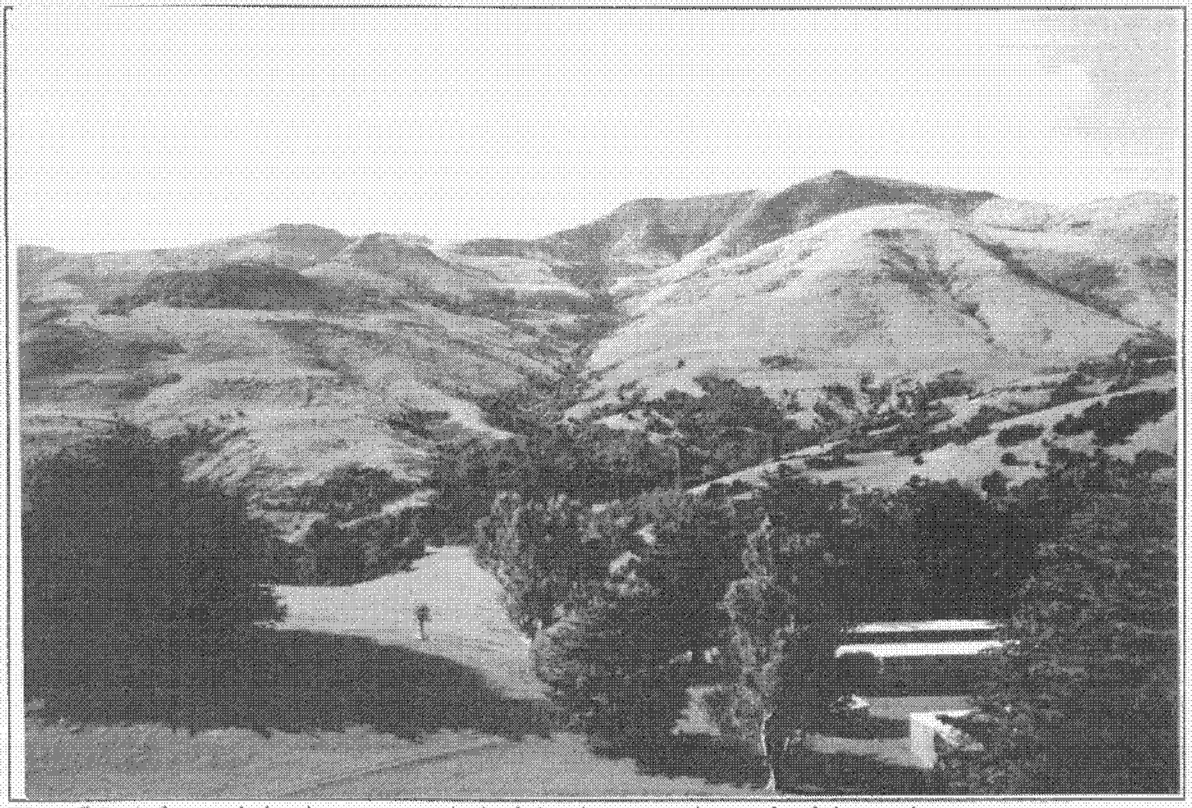

Plate 7.3: A forested riparian zone, typical of riparian zones in much of the catchment

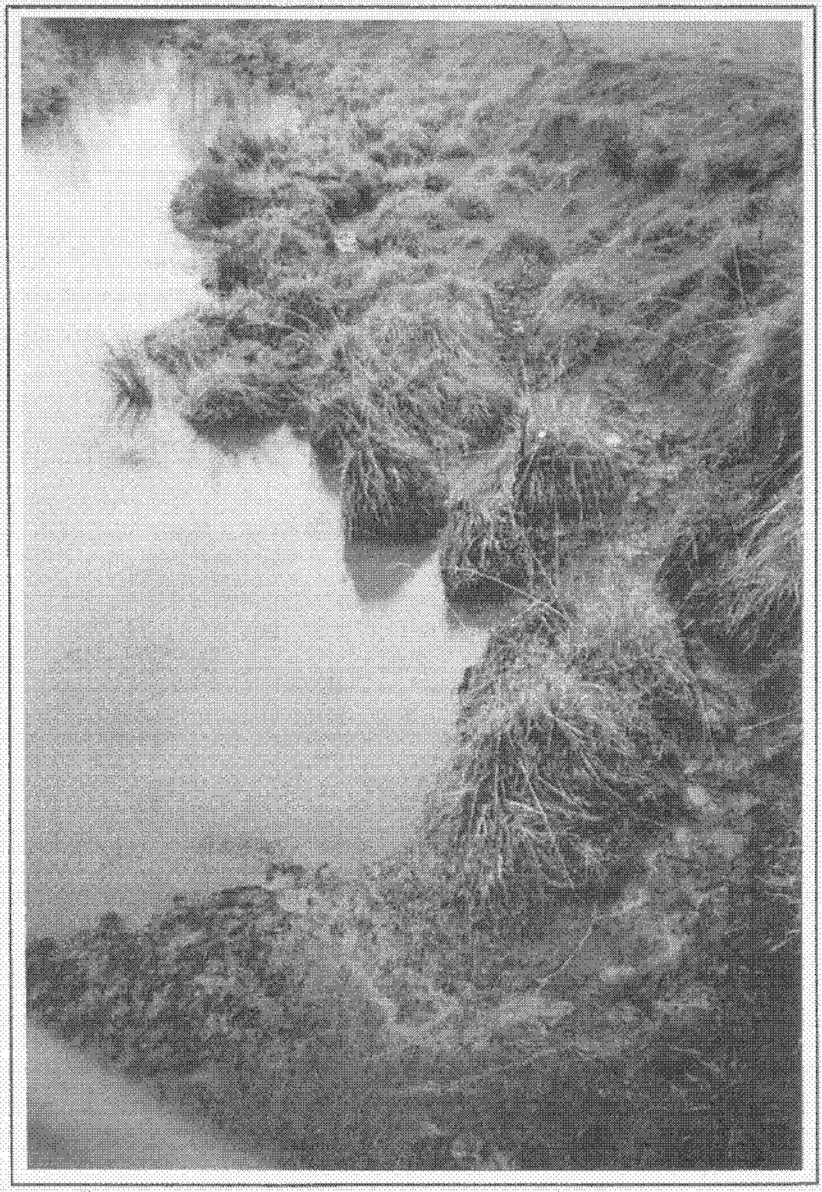

Plate 7.4: A typical riparian zone on the valley floor.

Deforestation

Deforestation leads to an increase in the size of flood peaks (Pearce et al, 1980; Figure 7.8). The amount of sediment, which includes nutrients, carried in streams tends to increase with flow (Richards 1982; Borman and Likens 1979; Ward et al, 1989), thus an increase in the size of flood-peaks will increase nutrient quantities in streams.

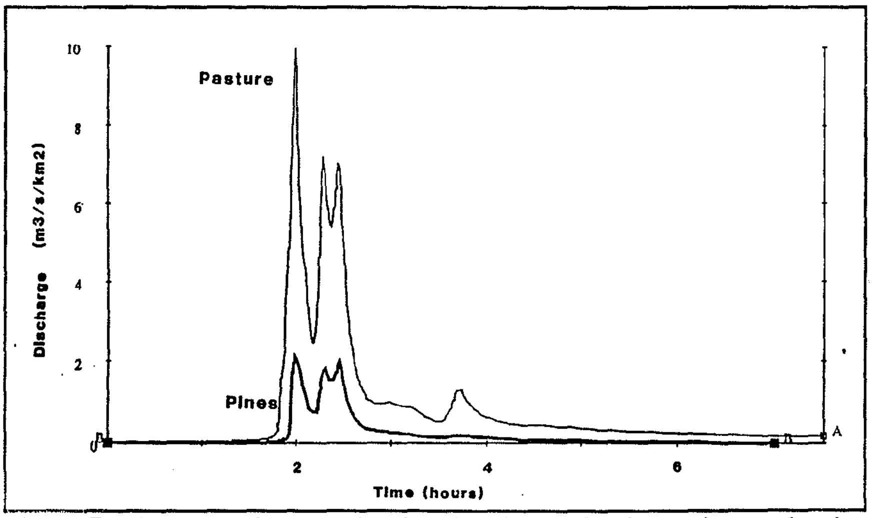

Figure 7.8: Hydrograph storm showing the effects of deforestation on the size of a flood peak (Duncan, 1988)

Sheep farming

Activities associated with sheep farming can cause nutrient levels in streams to increase. For example, until the mid 1890's wool was scoured in a stream flowing into Lake Forsyth (Hutchinson, undated); stock-yards situated near to a stream can be a source of nutrients (Hawkes Bay Catchment Board, 1989). There are some stockyards near streams in the Lake Forsyth Catchment. Nutrient from stockyards are likely to enter streams, particularly during storm events when overland flow may carry nutrients from the yards directly into adjacent streams.

Sewerage

All sewerage in the catchment is collected in septic tanks. Some of these overflow during rainstorms, according to locals, and sewerage flows into streams. Some of the sewerage created by the seasonal 'cocksfoot' workers (up to 1200) may have entered the streams also.

7.3.3 Seepage

Nutrients can also enter the lake via water seeping into the lake (Brock, 1985; Hawkes Bay Catchment Board, 1989). For example, seawater seeping into the lake (or flowing over the bar) contributes nutrients that are essential for nodularia growth. However, it seems unlikely that seepage alone could provide the large quantity of nutrients needed to make the lake so highly eutrophic (cf. fertilizer use).

7.3.4 Other inputs

Some locals suggested that nutrient enrichment could be attributed to fouling from geese. However, this seems unlikely because the geese are not present in huge numbers. In addition, geese can be viewed as nutrient storages and thus actually remove nutrients from the lake water.

Nutrients also enter the lake from the atmosphere. However, the quantities from this source are likely to be small because wind erosion in the catchment is minimal (Livingstone et al, 1985), and nutrients in rainfall tend to be negligible (Vant and Haore, 1987).

7.3.5 Re-suspension: Nutrient cycling

Flint (undated) suggests that large quantities of nutrients are being produced within the lake in a process known as nutrient cycling. Analysis of nutrient inputs supports Flint's suggestion, because small quantities of nutrients are entering the lake, yet the lake is highly eutrophic i.e. the nutrients must be coming from within the lake itself.

In a nutrient cycling process nutrients are released from the bottom sediments into the lake water (Brock, 1985). Nutrients in the sediments can enter the lake water via at least two mechanisms. Firstly, sediments (and therefore nutrients) can be stirred into suspension by wind-induced wave action. This is highly likely to occur in Lake Forsyth. Secondly, bacterial action in the mud can release nutrients into the lake water, especially when the mud becomes warm and deoxygenated (Vant, 1987; Hawkes Bay Catchment Board, 1989). Whether this bacterial process occurs in Lake Forsyth is unknown but in shallow lakes near Kaikoura Stout (1975) has found conditions ideal for bacterial action to occur in the sediments, and similar 'ideal' conditions may occur further south (300 km) in Lake Forsyth.

The sediment on the bed of Lake Forsyth consists of black mud (Plate 7.5). The black colour indicates high content of organic matter (nutrients) (Ward, 1991; Brock, 1985), which suggests that the mud is capable is capable of providing large quantities of nutrients to the lake water via nutrient cycling.

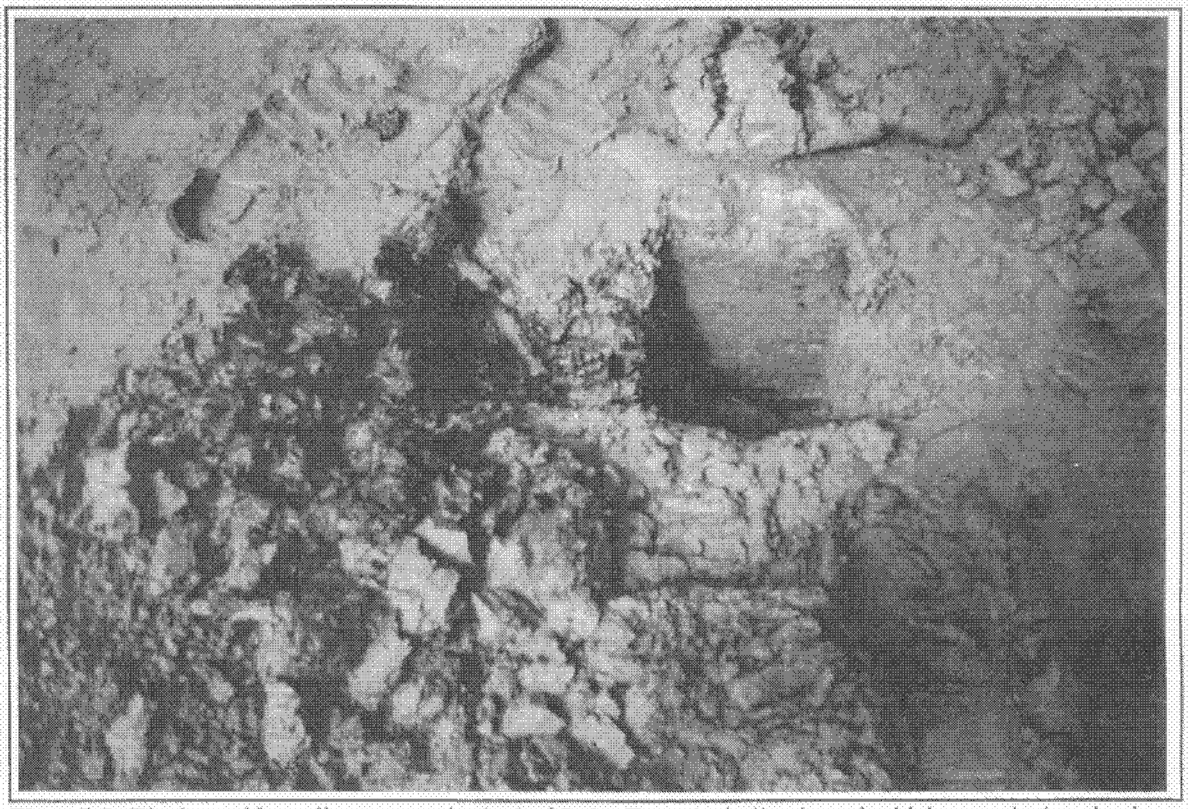

Plate 7.5: Black muddy sediments on the bed of Lake Forsyth, indicative of a high organic (nutrient) content (Photograph taken when lake levels were low).

7.3.6 A nutrient model

A nutrient model is (Figure 7.9) is based on the principle of nutrient cycling. The aim of the model is to show where the nutrients in the lake are coming from, while presenting the information in a clear manner, so that stakeholders are able to understand the processes.

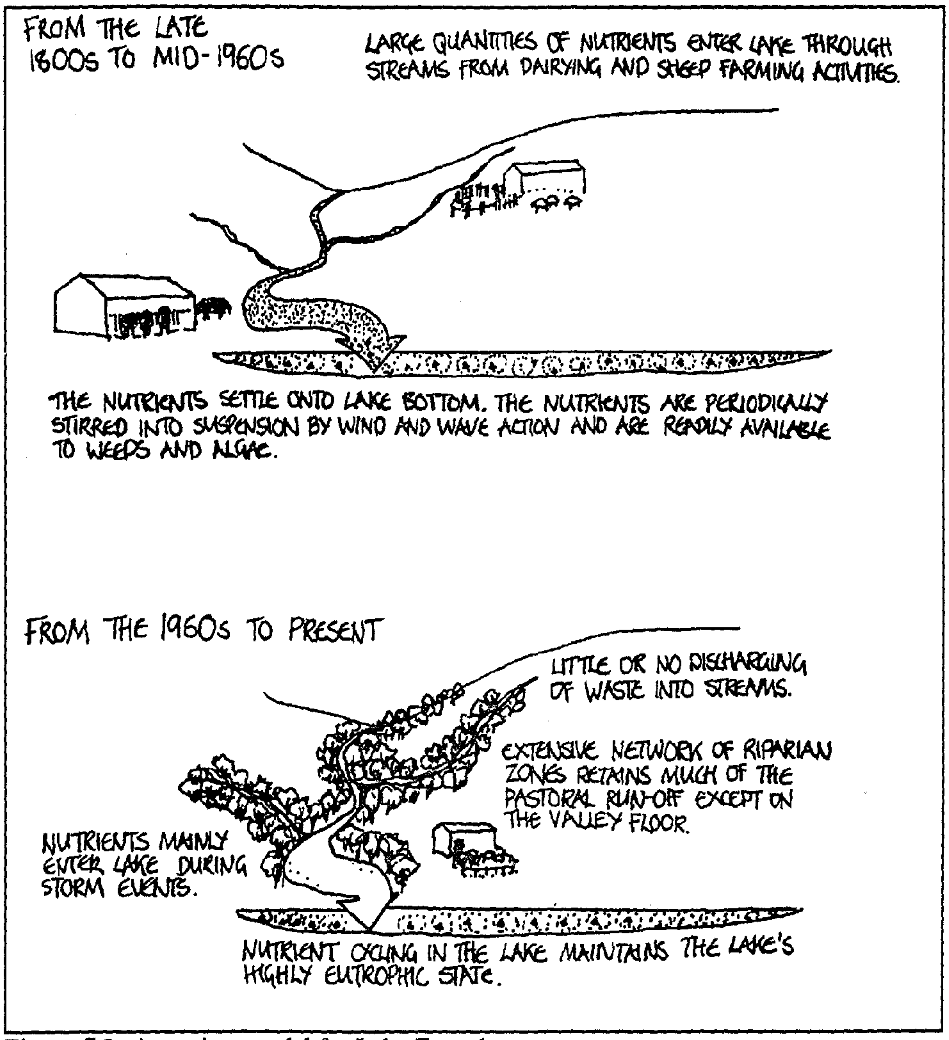

Figure 7.9: A nutrient model for Lake Forsyth.

7.4 Opening the lake

Opening the lake to control lake levels has been a major problem since the 1860's (Wairewa County Council files, and Little River Roads Board minutes). The way the lake opening process has unfolded is now outlined.

7.4.1 The opening process

From 1864 to the 1940's the lake was opened using horse-drawn scoops. Currently bulldozers are used to make a cut in the spit. Shingle from the spit is pushed parallel to the shoreline and large piles of shingle are created (Figure 7.10; Plate 7.6). It usually takes more than a day to open the lake; at times it can take four bulldozers a week. Opening the lake requires a calm sea. A heavy swell can obliterate days of work with bulldozers in a matter of hours (observed, 1991). The time and effort required to open the lake is a function of the height of the spit at the opening point[7].

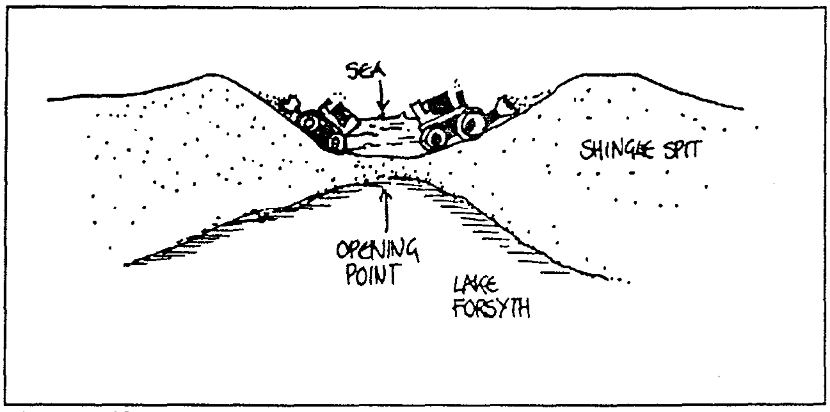

Figure 7.10: The method for opening Lake Forsyth.

Water flowing from the lake maintains a channel through the spit. The lake level needs to be at least 2 metres above sea level for the out-flowing water to scour a channel (discussions with Banks Peninsula District Council staff). When the lake level drops the outflow reduces, wave action (ocean swells) reworks the shingle and the spit reforms (Plate 7.7). The lake usually stays open for a week but on rare occasions the lake may be open for up to a month (records from Council files).

[7] Ignoring the wave climate during an attempt at opening.

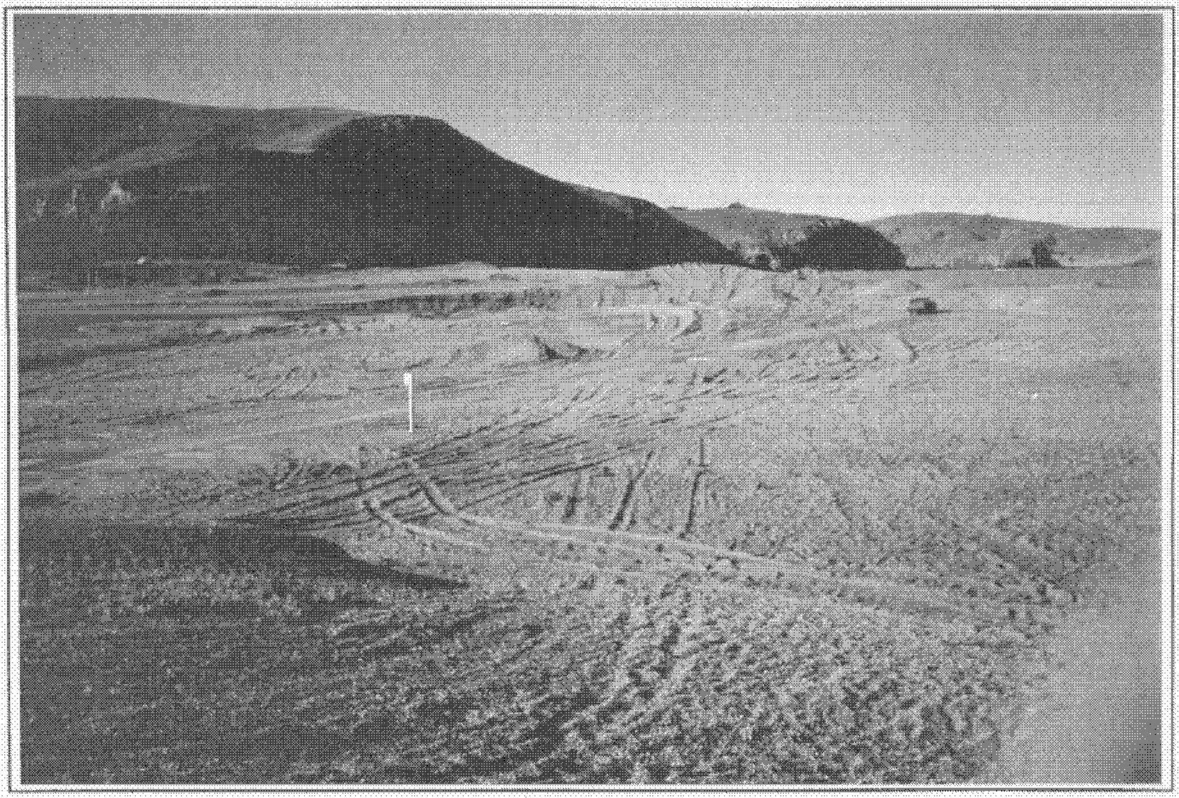

Plate 7.6: The opening point, showing large piles of shingle.

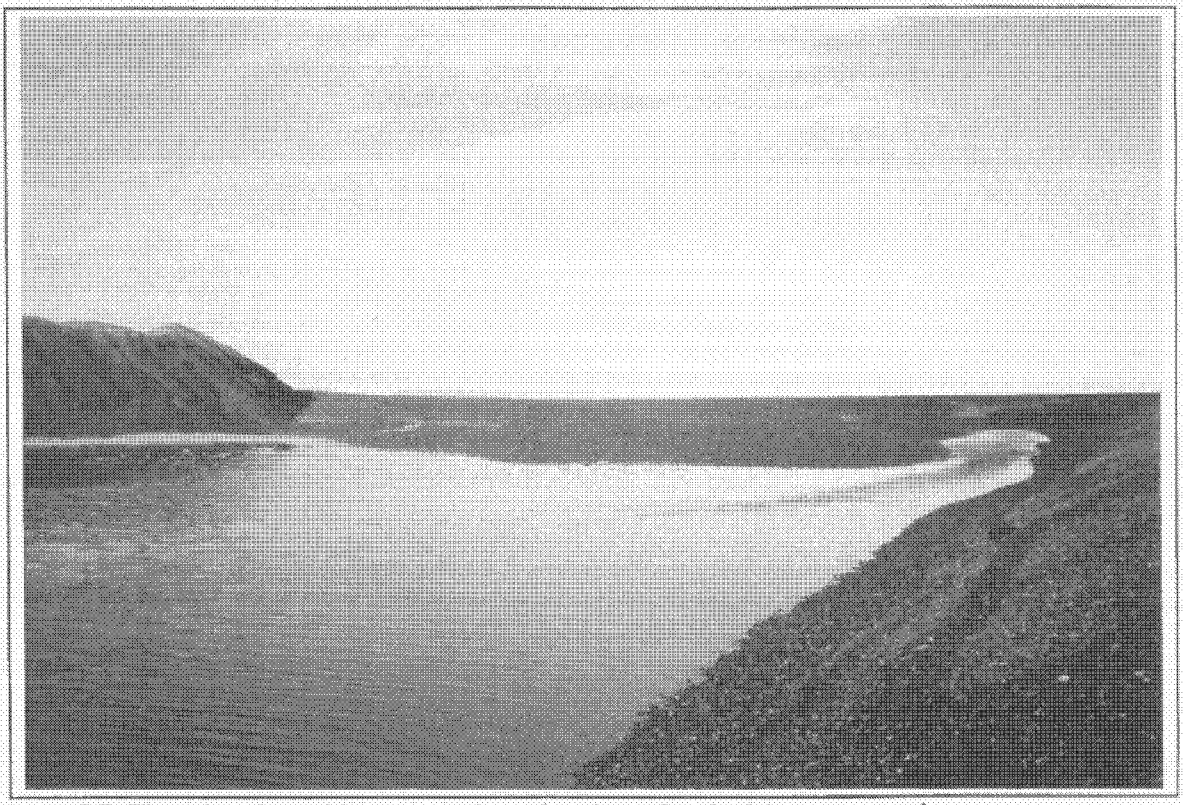

Plate 7.7: The spit, reformed by wave action a few days after the lake was opened.

7.4.2 A model of the outlet: small scale

The height of the spit at the opening point is increased by wave action (Figure 7.11). Small swells occur reasonably often at Birdlings Flat, while large swells are rare (observed during 1991). The height of the opening point progressively rises in a series of steps, and then falls suddenly (Figure 7.12).

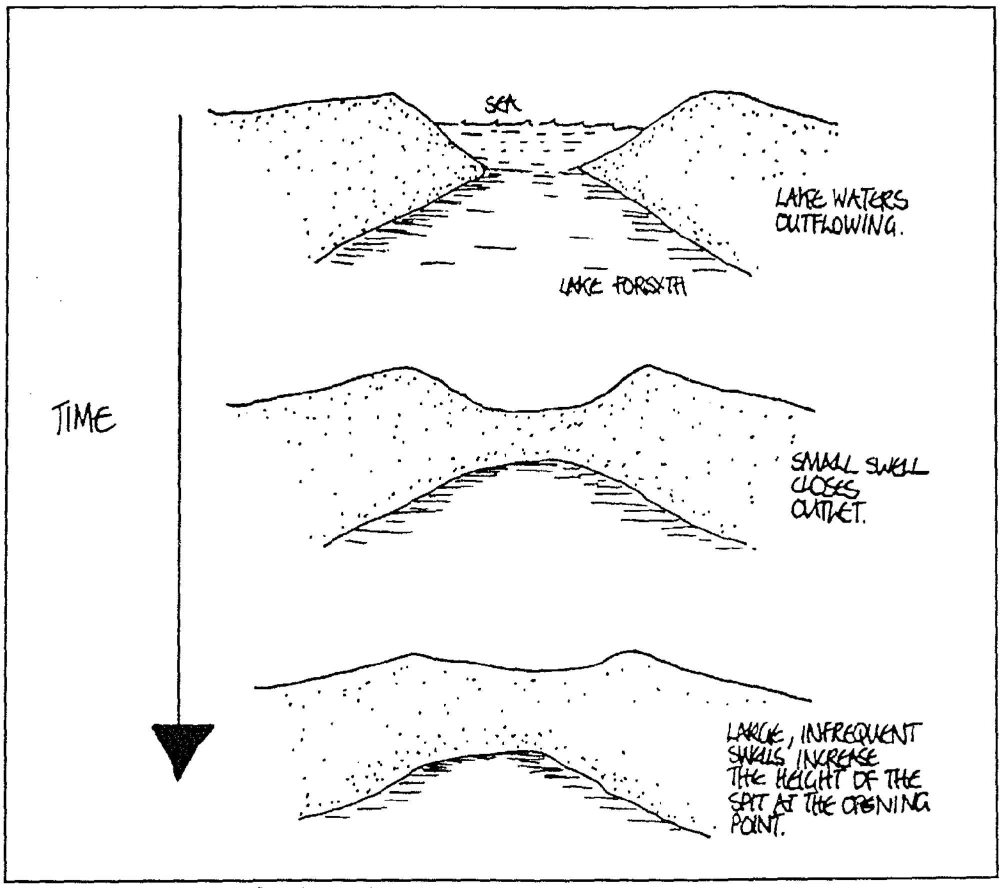

Figure 7.11: A model for the outlet.

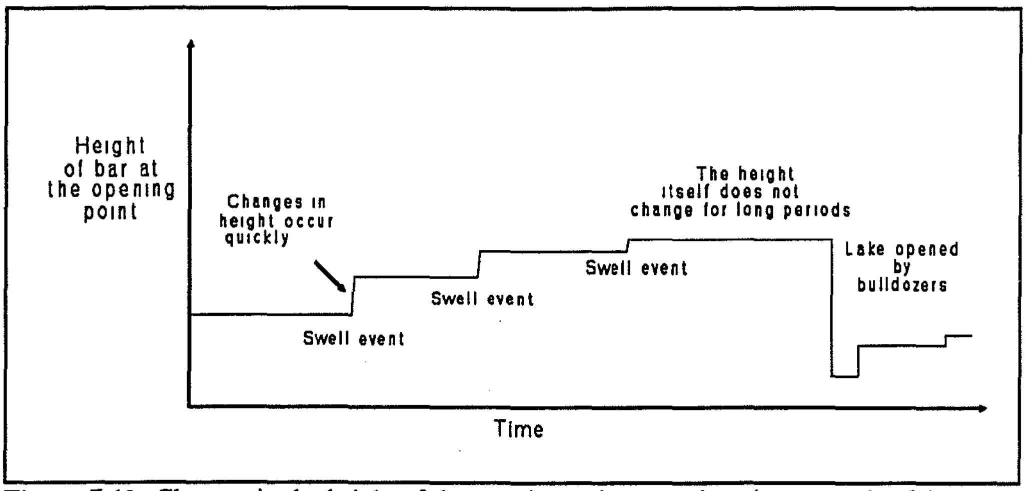

Figure 7.12: Changes in the height of the opening point over time (conceptual only).

7.4.3 Former times: Was the lake permanently open?

There is evidence to suggest that Lake Forsyth was open to the sea on a semi-permanent basis until the 1840's. For example; Maori oral history tells of Ngai Tahu ancestors sailing canoes into what is now Lake Forsyth (Nutira, 1991); whalers referred to the lake as Mowry Harbour and punted supplies down the harbour and out to the shore-based whaling stations (Hempleman, 1910).

However, there is also evidence which contradicts the suggestion that Lake Forsyth was open to the sea early last century. For example, Ngai Tahu eel-fishing traditions have developed for a closed lake (discussions with local Maori); a map of the outlet drawn in 1849 (the earliest map located) shows the lake closed (Maling, 1981). Thus, historical evidence concerning the outlet of the lake is not conclusive. A larger spatial and temporal scale is now used to develop a model of the outlet.

7.4.4 A model of the outlet: larger scale

South of Lake Ellesmere the coastline is in retreat whereas at Birdlings Flat the coastline has been advancing (Figure 7.12). When the beach at Birdlings Flat was well north of its present position the Peninsula would have sheltered the opening to Lake Forsyth from ocean swells (Figure 7.13). A sheltered wave climate would have significantly altered the processes occurring at the opening point.

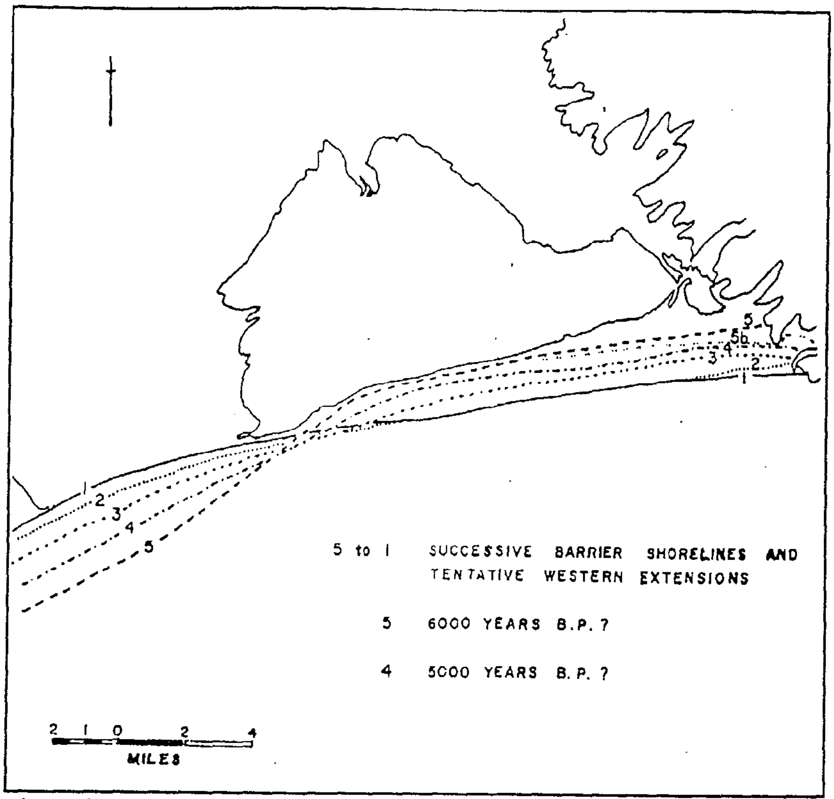

Figure 7.12: Recent coastlines between Lake Ellesmere and the Banks Peninsula (Armon, 1970).

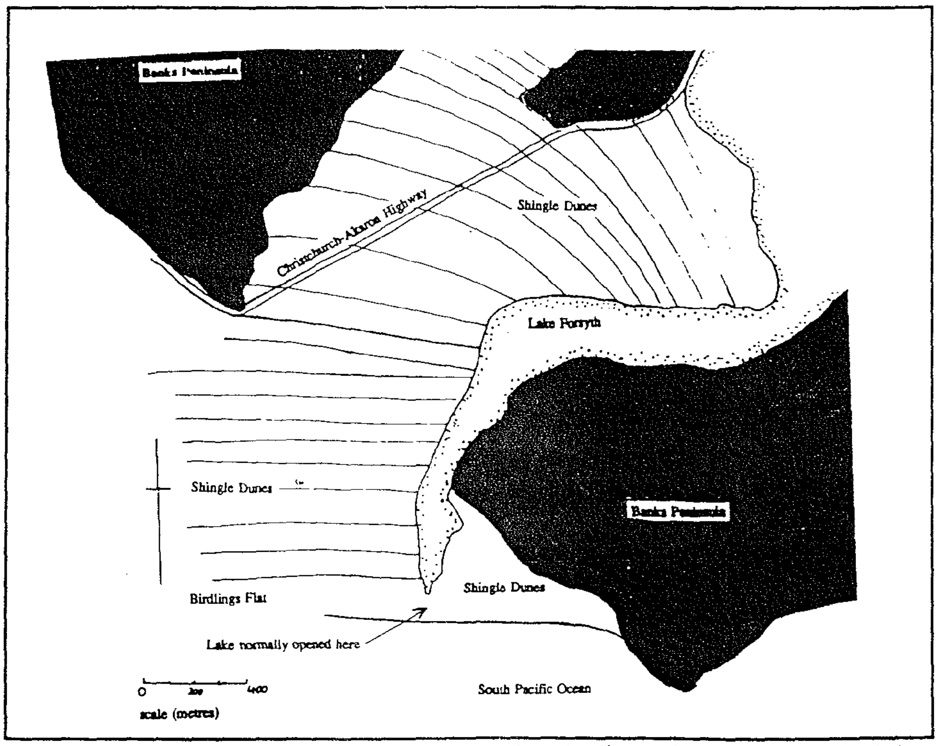

Figure 7.13: The outlet of Lake Forsyth, showing the lines of shingle dunes and the Peninsula .

The spit at the opening point would have been lower, because the height of the spit is related to wave energy. The lake would have burst through the spit when lake levels were lower, compared to the lake levels currently needed for a natural opening to occur. Therefore the lake would have opened more frequently. Larger and therefore more infrequent swells would have been needed to close the lake, once it opened. Thus, the lake would have been open for longer periods of time than it is at present.

In this scenario, Maori would still have had to develop eeling techniques for a closed lake. In Autumn, when the eels return to the sea (Skipper, 1991), the lake is likely to have been closed because streams tend to be at their lowest in autumn. Therefore, lake levels tend to be low at this time also, and the lake would not open itself. Thus, if the coastline only recently extended past a headland formed by the Peninsula (Figure 7.13) then early reports of the lake being open to the sea are likely to be correct.

There is evidence to suggest that a recent rapid advancement of the coast at Birdlings Flat has occurred. Armon (1970) suggests that beach advancement at Birdlings Flat has happened within the last 600 years. Royds et al (1970) state that the beach at Birdlings Flat has extended southwards 80 meters between the early 1870's and the 1940. Hempleman (1910, p206) states:

> *"Here, where Wairewa* [Lake Forsyth] *used to run out into the sea...the shingle accumulates - at a pace which there should be no difficulty in measuring."*

The advancement of the coastline appears to have ceased during the earlier part of this century (Royds et al, 1973) and the spit may now be thickening (Kirk, 1991; Skipper, 1991; Nutira, 1991).

A corollary to this model is that when European development began lake levels may not have been as high as they are capable of becoming now. If the height of the spit is rising flood hazard management could become more of a problem in the future.

7.5 Management

In this section approaches to managing human uses of Lake Forsyth are characterised. Firstly, management of the eel fishery is outlined, secondly arrangements for controlling lake levels are outlined, these two aspects of management being peculiar to Lake Forsyth. Thirdly, flood management in Little River is described, and fourthly, the way in which more general management decisions have been made is discussed.

7.5.1 Eel fishery management

A Maori committee has full responsibility for the eel fishery under the Fishery Regulations (1950; section 107 c(1))[8]. The fishery is managed according to traditional Maori customs. For example, eels can only be caught by gaff, and the concept of 'kaitiaki' is still used to a guide management (Ngati Irakau Maori Committee, undated).

7.5.2 Lake level management

The Banks Peninsula District Council obtains funding for opening the lake from rent collected from 2000 acres of farmland located near Lake Ellesmere. Late last century this land was gifted to a predecessor of the District Council, the Little River Roads Board, by the Crown to provide funding to open Lake Forsyth[9] and ultimately to pay for the construction of a permanent outlet (Armstrong, 1962). The 2000 acres of land was formally transferred to the Wairewa County Council's[10] ownership by the Reserves Act (1955)[11].

The Wairewa County Council sought various permanent outlet schemes over the years. All the schemes have been too expensive because of the extensive engineering works required to

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[8] The eel fishery in Lake Horowhenua, near Levin, is also managed by Maori, and is the only other lake in the country where Maori have exclusive rights to the fishery, according to local Maori.

[9] At that time the aim of managing lake levels was to ensure that the road to Little River, which ran alongside the lake, was not flooded.

[10] The Wairewa County Council was formed in 1910 and took over the functions of the Roads Board.

[11] Under section 21 of the Reserves Act (1955) the rent from the land must be used for:
"keeping Lake Forsyth at such a level as the Council shall deem expedient..." and *"... to construct drainage works by which the annually occurring losses and injury caused by the floodwater of Lake Forsyth may be prevented."*

ensure an outlet structure will withstand the heavy seas experienced on the coast (Council files). Rent from the two thousand acres is paid into the 'lake opening fund' and the fund meets the cost of opening the lake with bulldozers (discussions with Banks Peninsula District Council officers).

7.5.3 Flood management (stream overflows)

The Maori approach to flood management appears pragmatic. Maori settlements were built above the valley floor.

Flood hazard is managed by clearing obstacles from streams (Council files), and via planning regulations. A bylaw (District Scheme 1981) sets a minimum floor height for new buildings. To some extent the height bylaw formalised an informal management practice in Little River, because buildings were built with extra high foundations, as a consequence of the flooding risk (Bullman, 1991).

7.5.4 The approach to decision-making

The Wairewa County Council took responsibility for the lake's management under the Harbours Act (Council files). The County Council also took an interest in a range of issues and problems connected with the lake that were outside of its statutory responsibilities. Problems were dealt with in a piecemeal fashion the Council with little account taken of the connectivity of the problems. For example, the County Council sought solutions to the 'fly' problem, the 'weed and fly' problem, the 'algae' problem, the 'smell' problem (Council minutes, 15-6-1967, 26-11-69, 28-8-73, Council files, 5-4-68), but water quality, which forms the basis of the problems, was not discussed. On issues that were clearly not the County Council's statutory responsibility, the Council would act as an intermediary between conflicting users and agencies (Analysis of Council files).

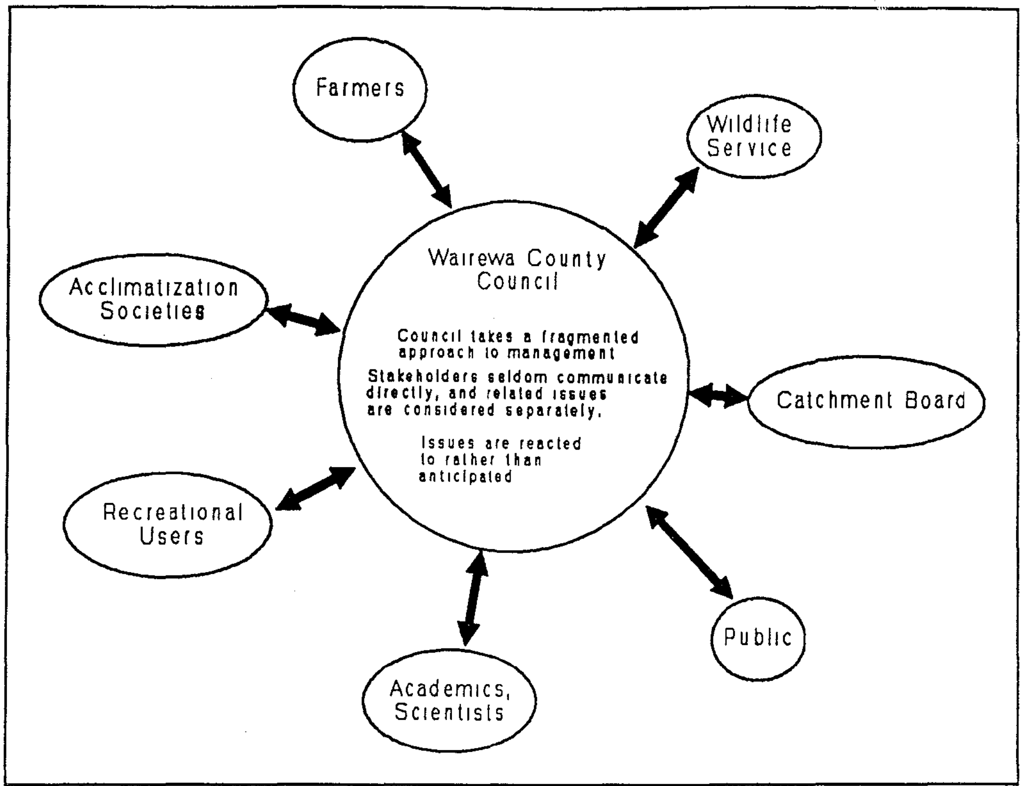

Figure 7.14: The decision-making process for management of Lake Forsyth, showing the lack of communication between stakeholders.

The approach the County Council used to lake management had reductionist characteristics (see Chapter Two). Problems were broken down into pieces (reduced), such as 'flies', 'weeds', 'algae' and 'smells'. Stakeholders were viewed separately (reduced) and were not encouraged to communicate with each other, except formally through the County Council (Figure 7.14). Few issues seem to have been anticipated and most issues were reacted to. The management approach has had a detrimental effect on the lake ecosystem, because problems were not adequately defined and were therefore not solved.

7.6 Management options

In this section management options are developed. Firstly, a bifurcation diagram is used to describe human impacts in the ecosystem and assess the ecosystem's state and define problems. Secondly, solutions are developed. Thirdly a 'vision' is created and expressed using a bifurcation diagram. Fourthly the applicability and relevance of a community-based 'action-plan' is investigated as a means of implementing solutions.

7.6.1 Problem Definition

The bifurcation diagram (Figure 7.15) clearly shows the effects the arrival of Maori and European has had on the ecosystem. Small species, such as lake flies and algae, have increased while large species, such as trees and fish, have reduced. Alternatively, the mauri could be said to be at a low level.

The ecosystem retains an imprint of past events. For example, the lake remains eutrophic even though nutrient inputs are now small; flooding occurs as a consequence of past development patterns, including deforestation, and the siting of human developments. Thus, the ecosystem needs redeveloping if its mauri is to be increased.

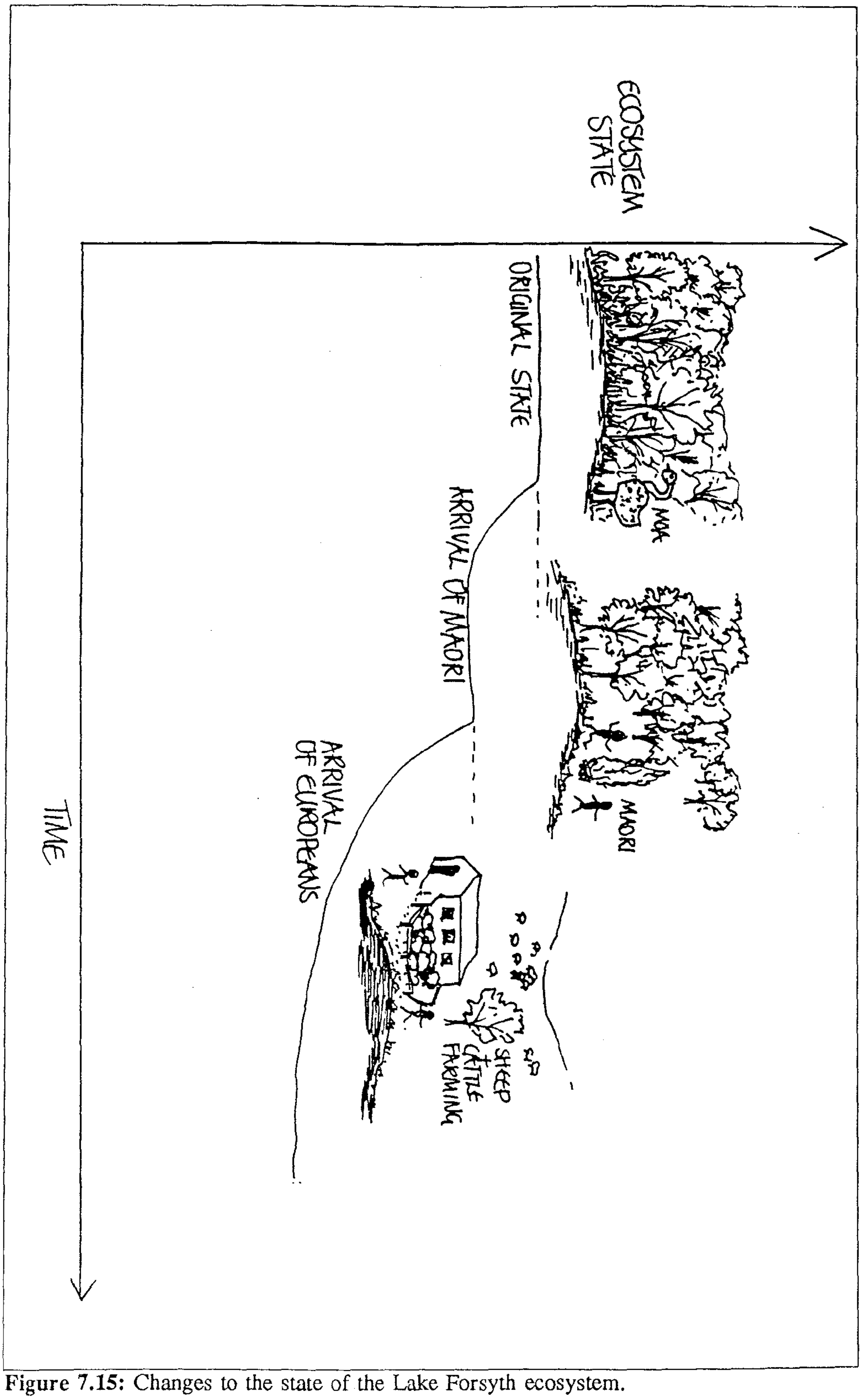

Figure 7.15: Changes to the state of the Lake Forsyth ecosystem.

7.6.2 Seeking solutions

In this section solutions are sought in terms of both ecological and social factors. The underlying principles used to establish solutions are that ecosystem complexity needs to be increased, risk to the ecosystem needs to be reduced, and solutions should involve the community so that the community can learn about their ecosystem. Solutions are outlined in terms of the following levels; the catchment, the lake, the lake opening, and human development on the valley floor (Figure 7.16). Thus, solutions are sought in spatially distinct ecosystems, while remembering linkages between ecosystems.

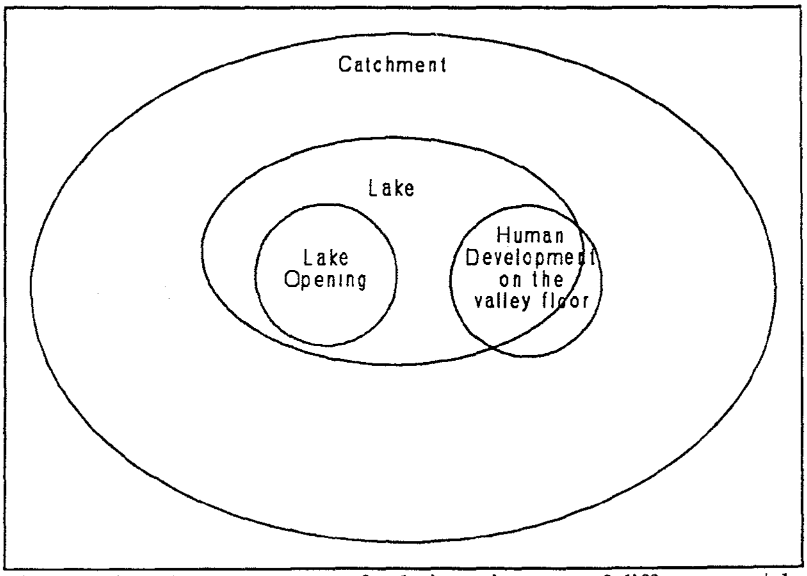

Figure 7.16: The arrangement of solutions, in terms of different spatial levels, showing connections and overlaps.

7.6.2.1 In the catchments

Complexity needs to be increased in relation to the following processes; pastoral run-off into streams, stockyard run-off, septic tanks discharges, rainfall run-off. These are now discussed.

Pastoral run-off

All riparian zones in the catchment should be forested (increased in complexity) to reduce nutrient flows in streams i.e. nutrient risk, such as eutrophication. Afforesting riparian zones has other benefits also, for example, the aesthetics of streams are improved, the fishery is economic benefit, stakeholders can be actively involved in riparian zone management such as tree planting, and much of the riparian zone on the valley floor is covered by the Queens Chain (belongs to 'The Crown') and would not have to be purchased from land owners (discussion with District Council Staff).

Stockyards and septic tanks

Further research is needed to qualitatively establish the risks posed by stockyards and septic tanks. For example, both the number of stockyards close to waterways and the number of septic tanks that overflow need to be established. Stockyards may have to be shifted or wetlands created to remove nutrients in run-off, if there is significant risk.

Rainfall run-off

Risks associated with both nutrient inflows and flooding are reduced by afforestation. Afforestation increases the complexity of hydrological processes[13], resulting in reduced flood peaks which in turn reduces nutrient loads and also flooding. There are large areas of the catchment covered in bracken and scrub (Plate 7.8; Figure 7.5 earlier), much of it at higher altitudes (Figure 7.17), that could be afforested either by natural regeneration, or by human intervention. Bracken and scrub have little value to pastoral-based agricultural production. These areas could be afforested without significantly reducing farmer's income from pastoral-based sources.

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[13] For example, forests cycle water within the canopy, act as a water storage, and increase evapotranspiration (Pearce et al, 1980), i.e. raise the complexity of hydrological processes, compared to grass cover.

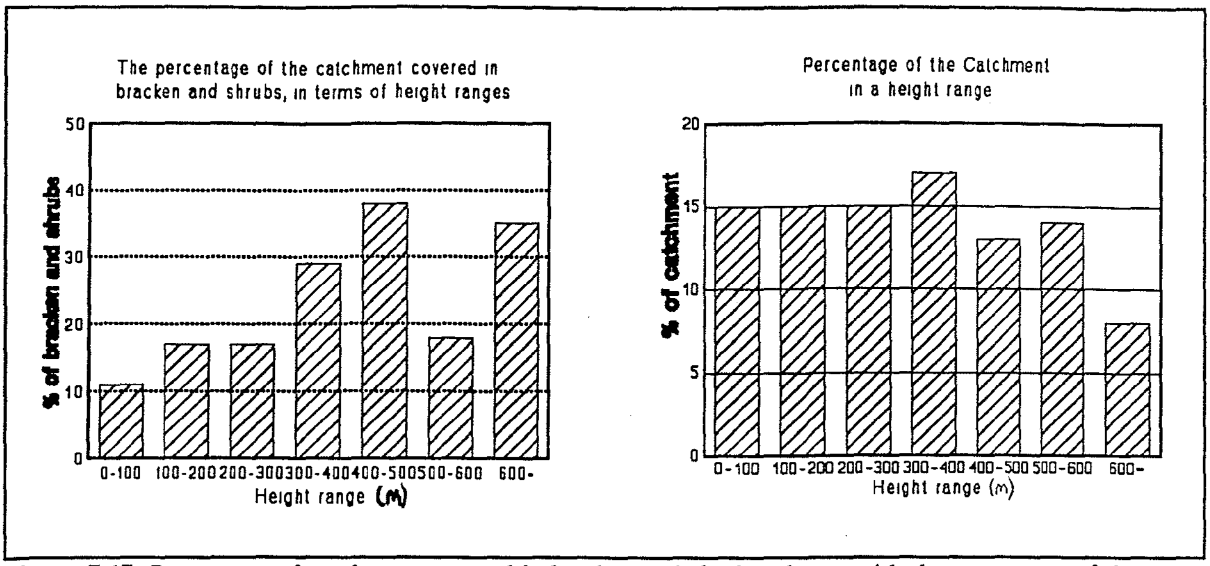

Figure 7.17: Percentage of catchment covered in bracken and shrubs, shown with the percentage of the catchment in a height range (data from Wilson, unpublished).

Afforestation could be subsidised using money from the lake opening fund, because afforestation will help to control the level in Lake Forsyth by reducing inflows. A proportion of the money earned from timber production in later years could be repaid into the lake opening fund.

There are many other aspects to be considered with an afforestation-based solution, such as aesthetics and landscape values. It is beyond the scope of this thesis to discuss these.

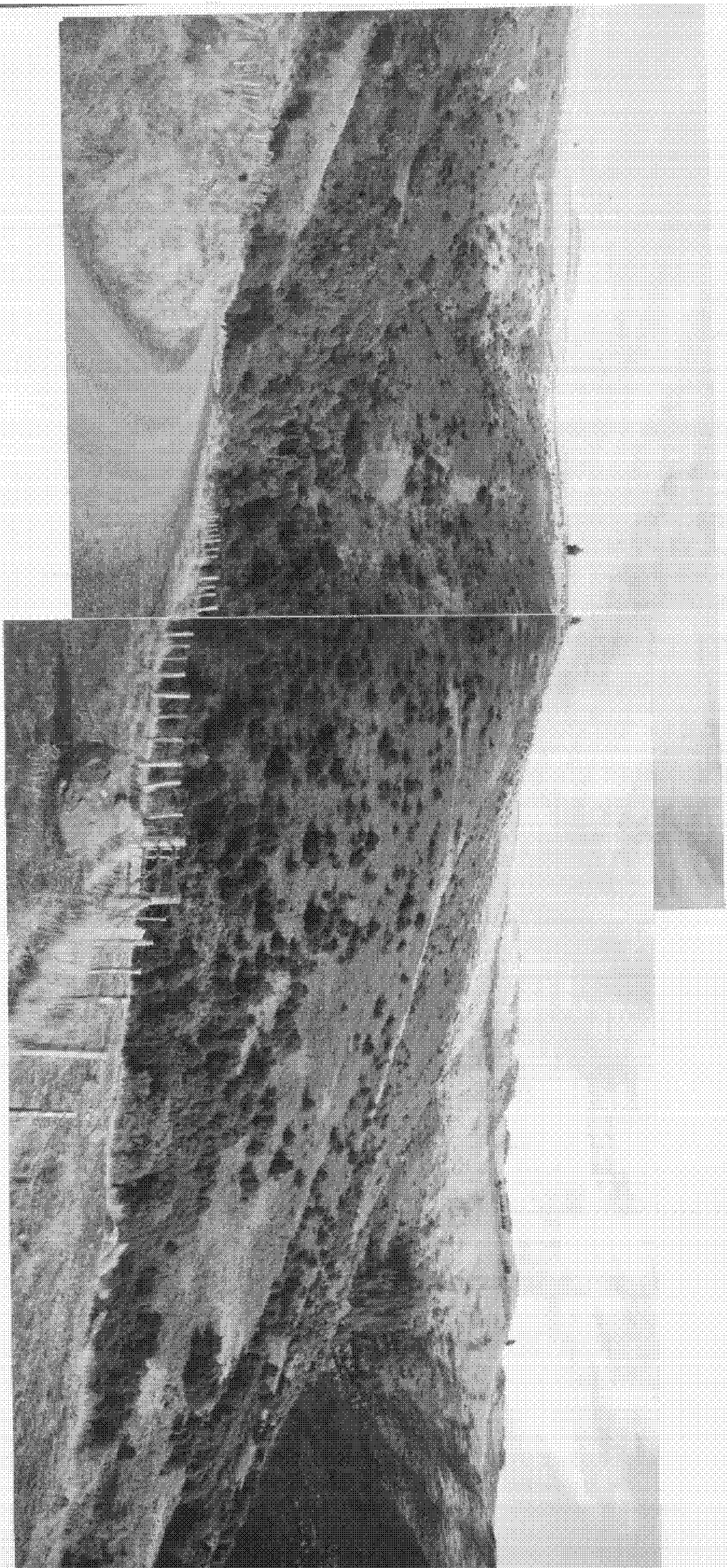

Plate 7.8: This area of bracken is typical of much of the catchment and could be afforested, either by natural regeneration, or by human intervention.

7.6.2.2 Within the lake

Nutrients within the lake are readily available to lower complexity life-forms, such as algae, via nutrient cycling. To raise the state of the lake ecosystem the quantity of nutrients being cycled needs to be reduced, and nutrients need to be shifted to higher complexity life-forms, for example, more trees and fewer lake flies.

Björk (1988) suggests that nutrient cycling can be reduced by dredging sediments, treating nutrients in situ by chemical precipitation, harvesting excessive weeds and large algae. However, the high costs of these options reduces their social acceptability. Smolyódy and Wets (1988) discuss the use of vegetation to remove nutrients from slowly flowing streams. This method applies to water entering a lake, however the method may have application to reducing nutrient cycling in Lake Forsyth.

At the head of Lake Forsyth is a large shallow area (Plate 7.9). This area could be planted with nutrient demanding species, such as flax and kahikatea (Wilson, 1991), to draw nutrients from the lake water, thus reducing nutrient availability to less complex life forms (Plate 7.10). Research into the ecological aspects of this solution is needed, such as determining suitable species.

Developing a nutrient reservoir within the lake has many socially acceptable features, including: the use of low-value land[14]; the area is already fenced from stock; ability for the community to become actively involved in the project, for example in tree planting projects; habitat creation for wildlife, which many locals spoken to consider desirable; vegetation, such trees suited to swamp conditions, could be harvested and sold providing income; the aesthetic appeal of the lake will be improved.

[14] Land that at present has low ecological and social values (including economic values).

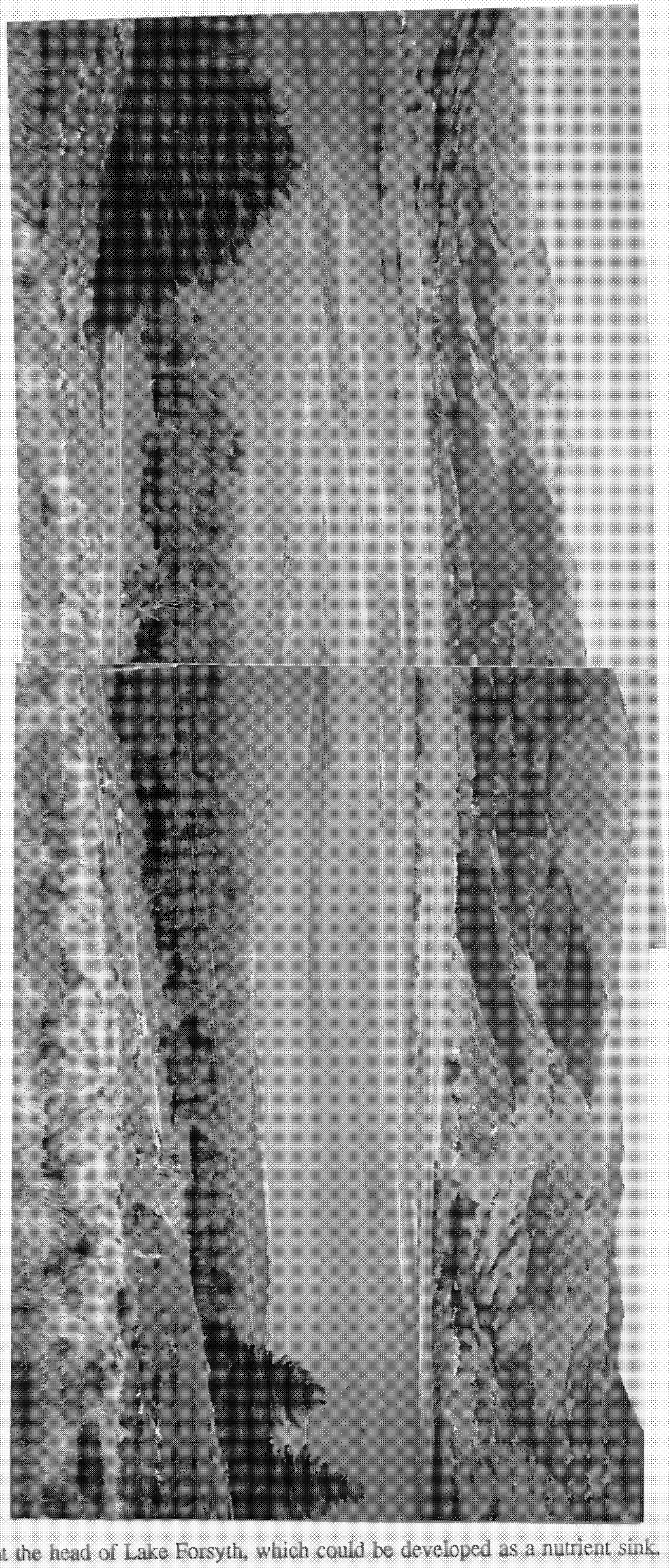

Plate 7.9: A muddy area at the head of Lake Forsyth, which could be developed as a nutrient sink.

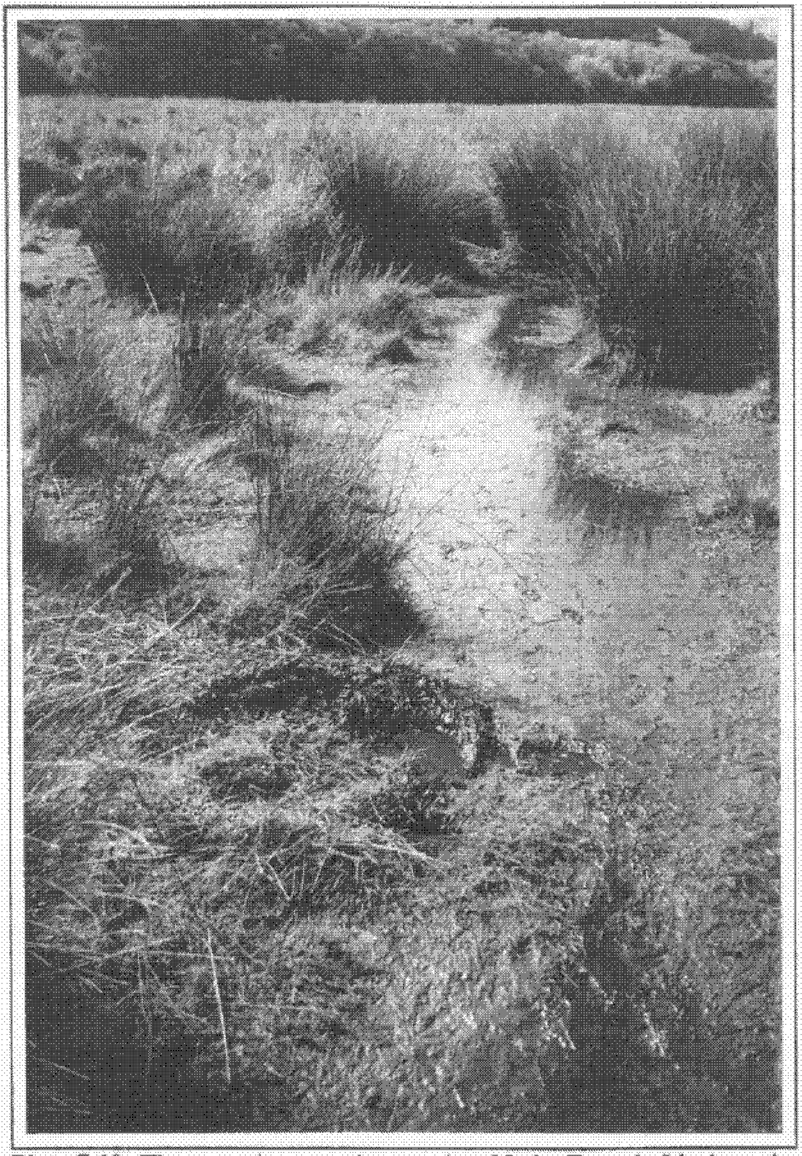

Plate 7.10: These nutrients on the margin of Lake Forsyth (black mud in the foreground) need shifting to a higher level of complexity.

7.6.2.3 Improving the lake-opening method

Increasing lake outflows will reduce flood risk. An outflow system that significantly reduces the risk of flooding must be capable of passing flows of similar size to peak inflows[15]. However, building a structure that will both discharge large quantities of water and withstand the high energy wave climate on the coast is difficult from the engineering point of view and therefore expensive (Davies, 1991; Kirk, 1991; Royds et al, 1973). Easier and quicker methods of opening the spit may be a better way to reduce flood risk.

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[15] Up to 200 cubic meters per second (Royds et al, 1973).

The ease with which the lake is opened depends on the height of the opening point. The opening point is raised by large swells which occur infrequently and lake opening can be made easier if the opening point is lowered by removing shingle after large swell events. The removed shingle could be used for crushing. Currently shingle is removed near Birdlings Flat at 'Browns Pit', creating an ever-increasing hole in the ground (Plate 7.11). The shingle on the beach appears similar to the shingle in Browns Pit and ought to be similar, because the shingle comes from the same sources (Canterbury Rivers) and has been subject to the same coastal processes.

This solution can be seen as increasing social learning and creativity. A problem in one area (too much shingle) and a problem in another area (an increasing hole in the ground) may be simultaneously solved by social organization.

There are technical and social difficulties to be overcome. For example, a good access road would need to be maintained across the shingle beach to the opening point, and the shingle extraction site must be 'tidy' because the beach is well utilized for recreation (observed during 1991). However, funding to overcome these difficulties could be obtained from the lake level control fund.

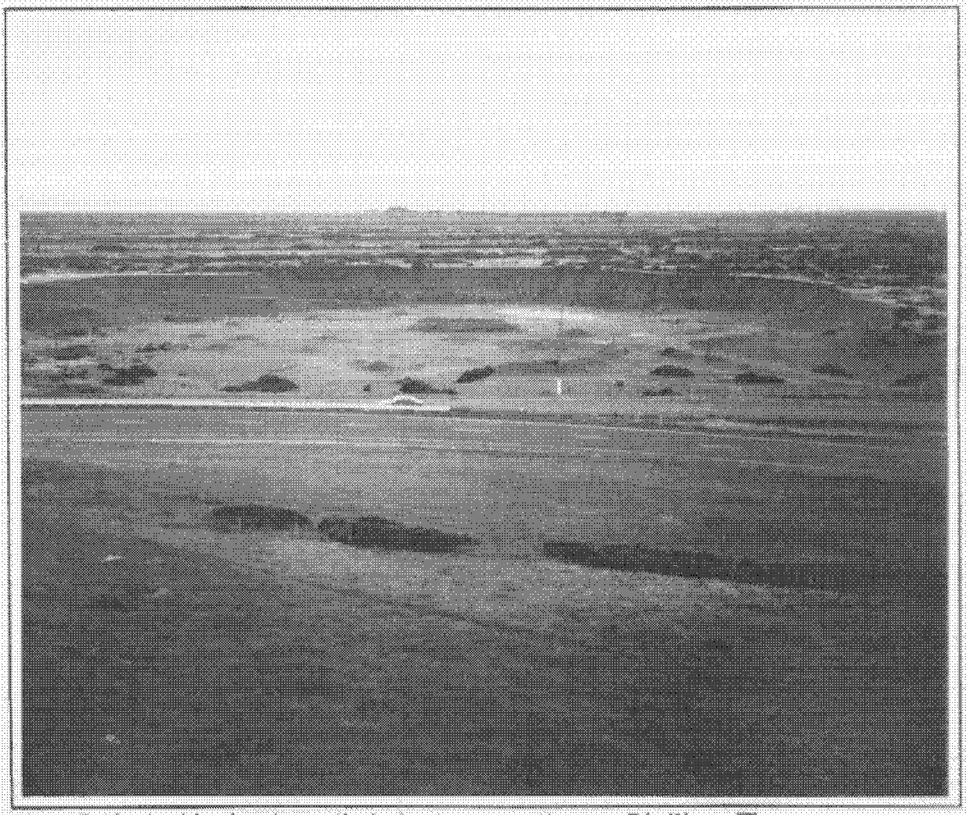

Plate 7.11: A shingle pit, or 'hole in the ground', near Birdlings Flat.

7.6.2.4 Altering development patterns to reduce flood risk

Development in areas that are not prone to flooding could be encouraged[16]. There are many areas near the valley floor that are suitable for building on and are free from flooding. Thus< halting development on flood-prone land would not significantly reduce the potential for development in the catchment. This option would be sensible if the spit at Birdlings Flat is increasing in height, because lake opening will become more difficult in the future.

This solution arises from an increases in 'learning' within the community i.e. the community 'learns' that certain areas are prone to flooding, and 'learn' to change their actions.

7.6.2.5 Solutions: Key points

Using concepts of ecological complexity, risk and 'learning' solutions have been formulated that simultaneously ameliorate a range of 'problems'. This is in direct contrast to conventional (reductionist) approaches that have sought to solve specific problems, without making linkages between them. The solutions are summarised in Table 7.3.

[16] To some extent this is already occurring, for example the District Scheme has set a minimum height above sea level for floor levels in new buildings. However, areas with high social value will continue to be flooded under the current approach, such as gardens, garages and sheds.

Solution described in terms of increasing complexity, or reducing risk	Risks that are reduced and benefits that arise.
Establishing a nutrient sink on the low-lying land at the head of the lake, to increase complexity within the lake.	Reduction in nutrients available to lower complexity life forms, such as algae. The aesthetic values of the lake are improved. The community can be involved in the scheme. Vegetation, such as trees, can be harvested for financial gain.
Afforesting riparian zones, especially on the valley floor, to increase complexity at the land-water buffer.	Reduction in nutrient-related risk. The fishery is enhanced. Trees can be harvested for financial gain.
Afforesting catchment areas, to increase the complexity of hydrological processes.	Increase in the value of land covered in bracken and scrub. Reduction in risk of flooding from stream overflows. Reduction in nutrient related risk. Trees can be harvested for financial gain.
Removing shingle from the opening point, by increasing social organization or 'learning'.	Reduction in risk of flooding. Reduction in the environmental risk associated with shingle pit usage.
Planning regulations to encourage development away from flood-prone areas, increasing social 'learning'.	Over time, less human development is affected by flooding.

Table 7.3: Key aspects of solutions

7.6.3 A vision

An example of a vision for the Lake Forsyth ecosystem is shown (Figure 7.18) in terms of bifurcations. The message from the vision is clear. For the ecosystem's state to change a fluctuation needs to occur in the social component of the ecosystem i.e. the component that caused the ecosystem to degrade.

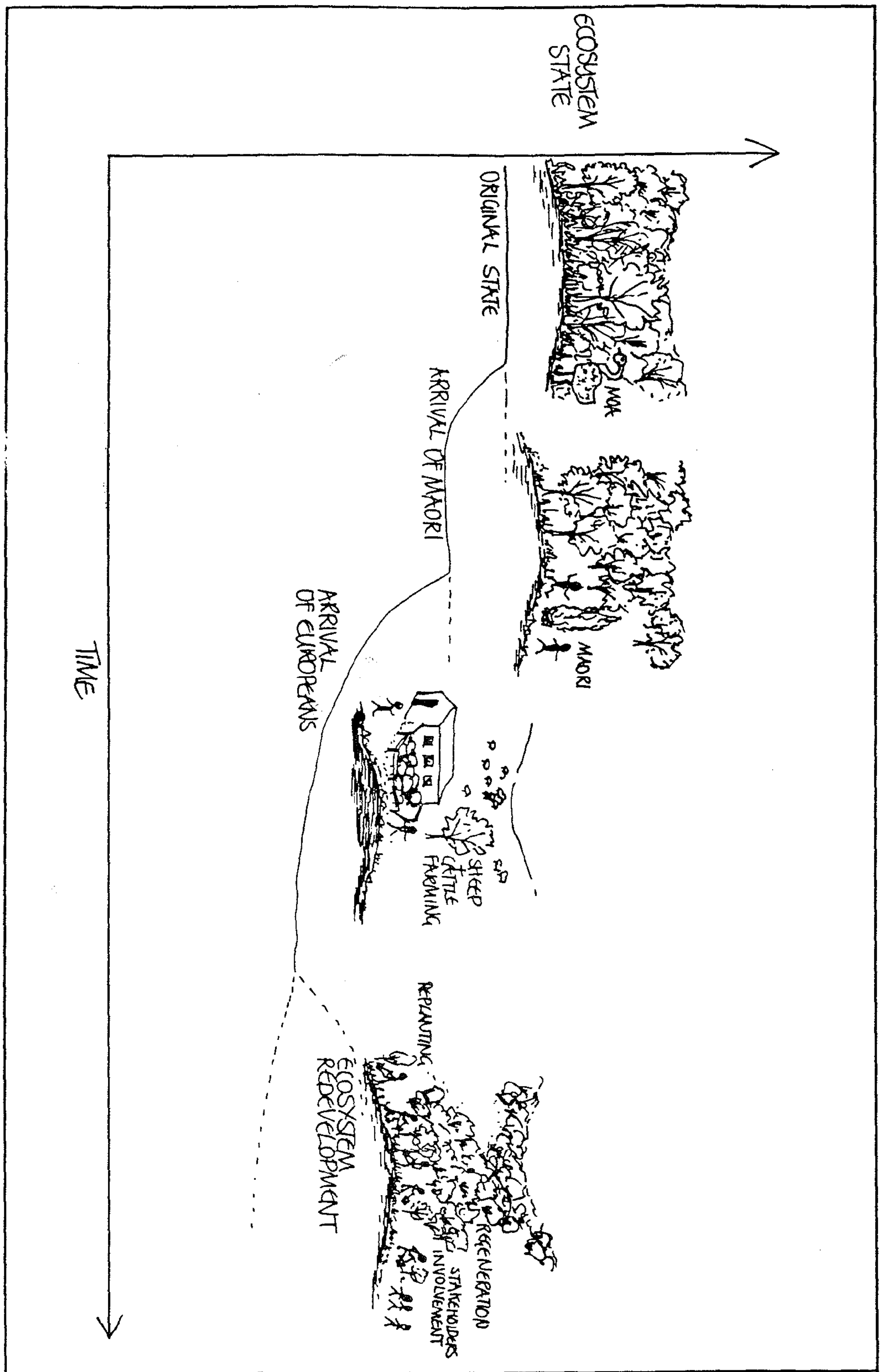

Figure 7.18: A 'vision' for the Lake Forsyth ecosystem shown in terms of the way the ecosystem has unfolded.

In this vision the people within the community act as a fluctuation and alter patterns, both social and ecological, within the ecosystem. A stakeholders group has responsibility for managing the ecosystem, the school is involved in the redevelopment of the ecosystem as an educational exercise, the economic base of the community is diversified through forestry and tourism, which increases as the beauty of the ecosystem is enhanced.

7.6.4 A community-based approach to management

There are reasons to strongly suggest that stakeholder involvement in the sustainable management (redevelopment) of Lake Forsyth is necessary and feasible. In the following discussion, the reasons are listed and supported. Information has been gained mainly through discussion with local people and representatives of the agencies involved management, both past and present.

Reason: Community empowerment is necessary and possible

Discussions with representatives from management agencies, such as the Regional Council, District Council and the Department of Conservation suggest that these agencies do not rate Lake Forsyth as a high management priority. Thus, an initiative for management needs to come from within the community.

Empowerment of the community seems feasible. There are active community groups that take an interest in the environment and community, for example, the Residents and Ratepayers Association, a Greensweep. A concert is being organised for February (1992) to raise funds for environmental projects in the catchment (Banks Peninsula Times 7:01:92). School children are involved in environmental and conservation activities as part of school activities, such as recycling, tree planting, and school children have participated in the traditional eel fishing methods[17]. In addition, user groups, such as rowing clubs may be prepared to be involved in the lake's management (Wylie, 1991). There is good communication throughout the community via the weekly 'school and community' newsletter that is delivered to every house in the catchment (Appendix 1). With good communication, active groups, and some willingness of educational institutions to take an active role in community development, further empowerment of the community seems possible.

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[17] The traditional eel fishing methods were an 'eye-opener' to both pupils and parents accompanying the pupils, according to locals.

Reason: Willingness of stakeholders to participate in management

Community groups are actively involved in management. For example, Greensweep runs a recycling centre with District Council cooperation, and the Ngati Irakau Committee manages the eel fishery. Representatives from groups in the community, such as the Ngati Irakau Committee and Greensweep, expressed a willingness to be involved in a stakeholders group that had management responsibility for Lake Forsyth.

Reason: The stakeholders are concerned about the lake's condition

All of the people I spoke to who used the lake or lived near to it were concerned with the condition of the lake and its environs (typical comments are shown in Appendix 2). In addition, the Waitangi Tribunal (1990) has found that the Lake's condition should be improved, and the Canterbury Regional Council[18] (1990) also acknowledges there is a problem with the lake. Thus, it is widely recognised that there are problems with the lake. Stakeholders are likely to welcome moves to improve the ecosystem, and may be prepared to actively participate in ecosystem redevelopment.

Reason: Stakeholders can take account of community aspirations more competently than management agencies

Many locals feel that management agencies do not take sufficient account of their views. Locals' comments were particularly directed to the District Council, which has a key role in the catchment's management. A stakeholders group should be better placed to take into account community aspirations, because stakeholders will be more representative of lake users and concerned citizens.

Reason: Stakeholder involvement can help ensure accountability

Currently, management agencies are not held accountable for their decisions. For example, some locals feel the District Council could use the lake-opening fund more cleverly, but locals have found the Council difficult to approach on this issue. A stakeholder group could help ensure accountability by scrutinizing the actions of a management agency.

[18] The Canterbury Regional Council has statutory responsibility for the lake's management under the Resource Management Act (1991).

Reason: The development of a sustainable pattern is dependent upon coordinating the actions of many individuals and groups

It is unlikely that regulations and planning alone will control all human uses of the ecosystem. Therefore, people who use the ecosystem must become aware of the consequences their uses have on the ecosystem (United States Environmental Protection Agency, 1990). This can best be achieved by involving users of the ecosystem in the definition of problems and the development of the vision, i.e. by encouraging 'learning' within the community.

7.7 Discussion and summary

The language and concepts of the unified approach have proved useful in aiding in problem definition, and helping define solutions. The bifurcation concept has been invaluable. This concept allowed humans to be viewed within the ecosystem, and the impacts of their actions could be clearly viewed in terms of changing the ecosystem state. The bifurcation concept suggests that to improve the state of the ecosystem the community has to act as a 'fluctuation' and move the ecosystem, including the community, to a higher state.

The pathway suggested by the application of the unified approach can only be tested in reality, which is beyond the scope of this thesis. It may also be impossible to model the suggested pathway due to social and ecological complexity. This is in direct contrast to reductionist approaches, which can be modeled, although the modelling results may have little relationship with reality.

An attempt to improve the ecosystem pattern (or increase the mauri) will probably be spearheaded by a few key individuals, who in open-systems terminology represent a fluctuation. But it will be the community and management agencies who allow the fluctuation to flourish. It remains to be seen whether people concerned about the lake will come together to develop a vision and formulate an action plan.

Chapter 8 Discussion, recommendations, conclusion

"Only when the relationship between an established community and its landscape - be it rainforest, desert or prairie - is fully understood, will landuse and that community be assured, through the economic thick and thin, of sustainability." (Jackson, 1991, p31).

"[To save the planet] *We must learn not only to behave differently, but to think differently. This is most difficult of all, as it requires us to abandon assumptions, change habits, create new models of thought, accept different values, and see the world through other eyes."* (Sir Crispen Tickell, 1991, in an address to the British Association for the Advancement of Science).

"... poems and songs can save soil [from erosion] *as well as studies in soil science."* (Wes Jackson, quoted in Blakeley, 1991, p5)

"And we have found that educated and concerned citizens are key to saving rivers and their riparian zones [from unsustainable development]." (J.D. Hair, President of U.S. National Wildlife Federation, 1988, pxiv).

8.1 Introduction and chapter structure

In this chapter the key features of the unifed approach are outlined at the conceptual level. The path that reductionism will take human civilization down is discussed, then future directions for research into sustainable management are suggested. The chapter finishes with the conclusion to the thesis.

8.2 Nature as an unfolding, learning process

The myth, or belief, that underpins the unified approach is that nature is an unfolding process. In the Gaia-based terminology ecosystems are continually changing, adapting as they travel down the 'bifurcation tree'. In Maori terminology the cosmic essence in the universe is continually being replenished, and nature is continually being created and recreated. The belief that nature is unfolding suggests that nature is learning as it goes along (Timmerman, 1986). This concept of learning may be an inherent fixture of the universe, and may be present in the matrix of all things (Jantsch, 1982).

Management approaches based on the myth of an unfolding and learning nature are adaptive and inclusive of community. Both the management system and the people within the ecosystem must continually adapt, change and 'Learn', as the ecosystem and The Biosphere learn and change. Therefore, this thesis is in agreement with Holling's (1978) principle of adaptive environmental management, and Checkland's 'soft systems methodologies' (Checkland, 1981b; Davies and Ledington, 1988). Thus, the task for resource managers is to assist communities in the process of learning.

8.3 Reductionism: a recipe for disaster

The myth of an unfolding nature is not part of reductionist science. In the reductionist view nature is a machine (static) and is therefore inherently predictable. Reductionist management approaches seek to understand nature sufficiently so that prediction and control become possible.

But the unfolding view suggests that nature's response to management cannot be predicted with any certainty because nature re-organizes and learns. The reductionist approach that expects nature to be predictable or controllable is very likely to have unexpected or 'surprise' outcomes, which can often be termed 'environmental disasters'. To avoid further environmental disasters humans must learn and adapt as ecosystems learn and adapt. For people to learn, communities must become empowered to learn.

8.4 Directions for future research

The process of empowering a community to learn about itself and its ecosystem is a key feature of sustainable management as seen by the unified approach, and a key feature of 'ecosystem approaches' (Hartig and Hartig, 1991). Methods for empowering communities and enabling communities to take responsibility for decisions are required.

Techniques for empowering communities are evolving around the world. For example: In the Great Lakes Region resource managers are developing methods for involving community (Barrett and Kidd, 1991); in the area of environmental risk assessment communities are being consulted about the risks they are willing to accept (Rosenthal and Johnson, 1990); landcare groups in Australia are leading to community empowerment and more sustainable land management (Cameron and Elix, 1990); in the so-called developing countries the technique of 'Rapid Rural Appraisal' is being used empower communities (Freudenberger, 1989); 'social learning' is being used to redesign fisheries management in North America (Dale, 1989). Thus, methods for empowering communities are being developed; however further simple and pragmatic steps need to be developed to enable ecosystem approaches to be implemented at the 'grassroots level' (Hartig, 1991).

To achieve sustainability ways of enabling communities to learn as their ecosystem learns are needed, rather than further reductionist science. Research should focus on methods to empower communities, rather than technical and sophisticated research that seeks to accurately predict future outcomes: Outcomes cannot be accurately predicted, because nature 'Learns' and adapts.

Conclusion

The following points emerged in the development of an approach to sustainable management.

Nature is an unfolding, evolving process. Ecosystems and The Biosphere are continually learning, changing, and adapting. Future ecosystem states cannot be predicted with certainty.

The reductionist belief that nature is predictable and therefore controllable, which currently forms the basis for many management approaches, is likely to lead to surprise outcomes, which are known as 'environmental disasters'.

Sustainable management requires a community to learn and adapt as ecosystems learn and adapt. Science and management must be supportive of community, and nurture community, and actively seek methods to enable communities to learn alongside their ecosystem.

Future scientific research should be redirected towards discovering methods of adaptation, rather than methods of prediction. This requires more research into community relationships with their ecosystem, and far less research into trying to increase predictive abilities.

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ESTION OF THE WEEK: Who was the cunning cricketer who didn't attend his usual Friday night session, but instead cooked tea for his family (scoring valuable Brownie points), but spoilt it all by getting home very, very late after cricket on Saturday?

urs sincerely,
W: Dunn,
incipal.

COMMUNITY NOTICEBOARD

MMUNITY CARE: Meet at Playcentre at 10.30am, where will have morning tea with the children and see eir activities. From there .. a mystery tour! ing own lunch. Ring Marg 290-807 or Pat 251-086 if u need transport.

CIAL WALKING: Walk the Kaituna Reserve, Tuesday 29 tober. Bring packed lunch. Meet at Craft Station .00. Sunday 10 November walk the Montgomery serve followed by the Hay Reserve Pigeon Bay. Meet the Hilltop car park 1.00pm.

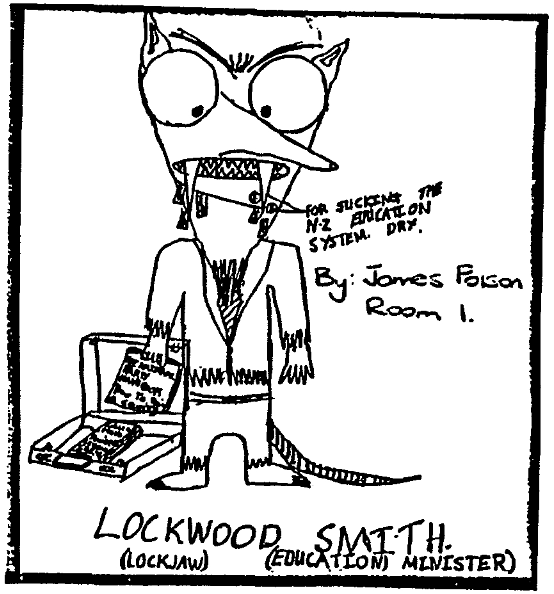
AFT AND ART TRAIL 1992: Akaroa Community Arts uncil are now producing a new, more "up-market" sign brochure. Still only $35 per entry. Phone byn McFarlane 251-119 if you need an entry form.

CYCLING SUPPORT GROUP: A Green Sweep is in need of tra parents support at the Depot on Wednesday ternoons 1-4pm and Saturday mornings 9-11am. Please one Jenny Taylor 251-043 for roster advice.

TTLE RIVER NETBALL CLUB: A General Meeting will be ld in the Clubrooms, Tuesday 29 October 7.30pm. in point of discussion: Banks Peninsula Annual neral Meeting and our remit on men in netball. ease try and attend this important meeting.

ICKET DRAW SATURDAY 26 OCTOBER.
ttle River versus Awa-iti.

Little River School & Community Newsletter



No.27 24 October 1991

Appendix 1: The community newsletter

The school and community news letter that goes to every house-hold in the catchment.

[illegible]
Social Walking.
Community Care, Mystery Tour.
Plunket Health Day.

VEMBER

Athletic Sports, Akaroa, postponement date Friday 8 November.
Social Walking.
Tuesday School.
School closed, Show Day.

HOOL PROGRAMMES: Over the next month the staff and self will be focusing on next year's programme. We ll be discussing the budget for curriculum areas, o subject areas to be our major emphasis for the ar, staff appraisal and development programmes and e arrangement of classes for the year. We will so be evaluating the effectiveness of this year's ogramme. In terms of evaluation new forms of porting to parents may also be discussed. If you uld like an input, especially on the major subject eas for the year, please phone me with your ideas.

T SHOW: The Pet Show Committee will be meeting at 30pm at school this evening. We plan to discuss the te, the programme and overall arrangements for the t Show. If you have any ideas or wish to attend ease feel free to attend or phone with suggestions.

AFF APPRAISAL: I attended an interesting two day urse on appraisal this week. Appraisal is a latively new idea on the education scene and is t to be confused with the old inspectorate system. is an in-school review looking at the things we as dividual teachers do well and things that we need develop further in a professional way. Appraisal based on individual teacher's job description and y only focus on a few of the items in the job scription. The Principal has a further appraisal in rms of a Performance Agreement which is discussed d agreed upon by the Board Chairperson and the incipal. The Chairperson and the Principal meet roughout the year to see whether objectives have en achieved. Likewise for staff objectives set for em after appraisal are also discussed to see ether goals have been reached. Most New Zealand hools are only beginning appraisal and all schools ll have an individual school policy on how it ould be done and how often.

New Zealand has the highest incidence in the world of melanoma, and it is our duty to see that our children do not suffer later in their lives. With a very hot day yesterday, the absence of sunscreen and hats among our children was very obvious. While I respect individual rights, I would be appreciative if parents and children discussed this matter and decided on a course of action, without the Board putting a policy in place.

CRICKET: The cricket coaching on Tuesday was very successful. Congratulations to Charles Evans, Josh Sage and Anthony Moore on being selected in the Peninsula Primary Schools' Cricket team. Luke Robertson has also been selected as non-travelling reserve. Well done boys!

NEW CUP: The Board has accepted an offer of a new cup donated in memory of Ron McAuliffe by his sister. Ron was apparently a very good pupil, a very good horseman and sportsperson. Ron was a Flight Lieutenant with the R.N.Z.A.F. in World War II and was killed in action. We have yet to decide what the cup will be presented for e.g. sportsmanship, citizenship, but will make a decision shortly.

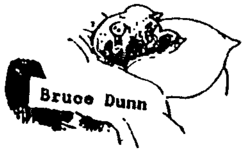
FIRE CALL-OUTS DURING SCHOOL DAY:

As I have reactivated my status as a Volunteer Firefighter I have spoken to the Board about my responding to call-outs during school time. It has been decided that I should attend as during the day the Brigade can be stretched to the limit. Because the school is close to the Fire Station it is very probable that I would be the first on the scene and would become radio operator. On days when Mrs Brice is working she would attend to class needs, on other days pupils would be able to come to the hall, after the appliance has departed, and organise games or carry on with their work. Mrs G. McFarlane has indicated that she would be able to look after class on these days.

nterested girls, on Tuesday October 22 boys and at the omain. I have not spoken to the coaches, but I resume that any intérested parents would be welcome o attend.

UESDAY SCHOOL: The next Tuesday School has been hanged until November 12.

QUESTION OF THE WEEK: Who is the person who sleeps for ages on Saturday mornings and arrives late for cricket?



COMMUNITY NOTICEBOARD

TTLE RIVER NETBALL CLUB: A General Meeting will be ld in the Clubrooms, Tuesday October 29, 7.30pm. in point of discussion: Banks Peninsula Annual neral Meeting and our remit on men in netball. ease try to attend this important meeting.

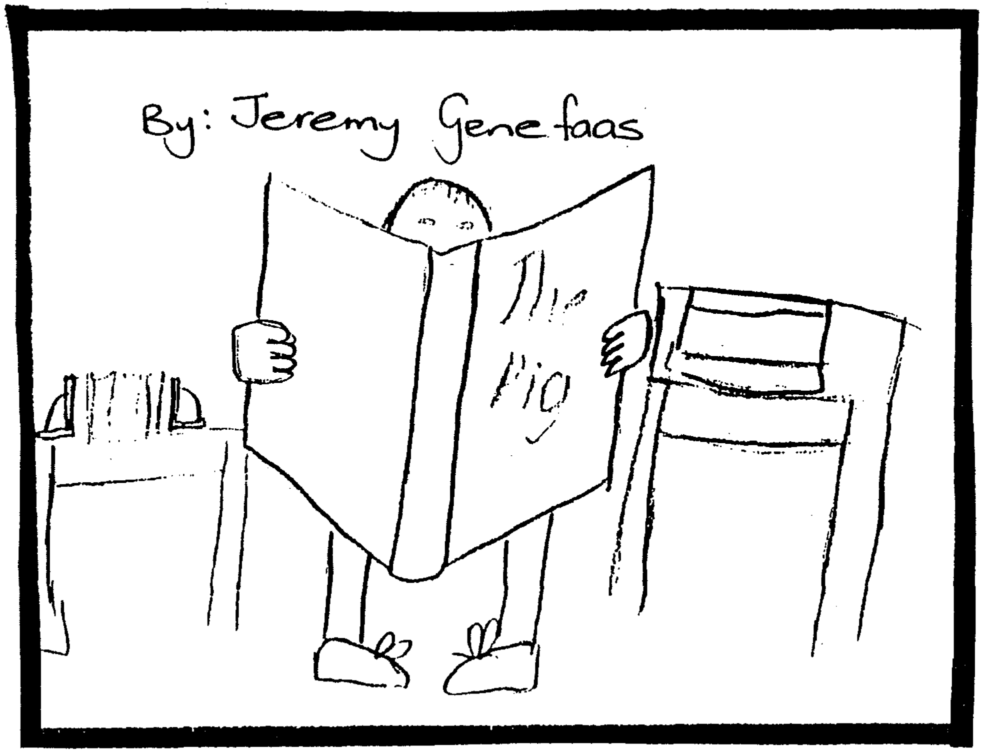
CIAL WALKING: Walk Onawe Peninsula, Tuesday 22 tober. Bring packed lunch. Meet at the Craft ation 10.00. If wet Thursday 24. All welcome.

MMUNITY CARE: Meet at Playcentre at 10.30am, where will have morning tea with the children and see eir activities. From there ... a mystery tour! ing own lunch. Ring Marg 290-807 or Pat 251-086 if u need transport.

ICKET DRAW OCTOBER 19: Little River versus Diamond rbour at Diamond Harbour. Awa-iti versus Wainui at me.

MEN'S HEALTH DAY: Please have flowers at the mmunity Centre at 1.00pm tomorrow, (Friday) not 00pm.

Little River School & Community Newsletter



No. 26 11 October 1991

COMING EVENTS

OCTOBER:

19 Rural Women's Health Day.
19 BOT, Monthly Meeting.
24 Social Walking
28 School closed, Labour Day.
29 Netball Club, Meeting.
30 Community Care, Mystery Tour.
31 Plunket Health Day.

NOVEMBER

5 Athletic Sports, Akaroa, postponement date Friday 8 November.
12 Tuesday School.
15 School closed, Show Day.

WELCOME: I would like to welcome Lydia Ringle-Harris to the school and hope that she enjoys her years of schooling.

PRINCIPAL'S COURSE: I now know what it means to be at school again, after three days and nights of intensive listening, concentration, writing and sitting whilst on this course. Course members came from as far afield as Glenavy (Waitaki Bridge), to Takaka. School sizes ranged from fifteen teacher (Woolston) to quite a few sole charge schools. There was one other 3 teacher school (Brooklyn, Nelson). There were 3 rural advisers running the course from Timaru, Christchurch and Nelson as well as an adviser on School Management. All of the principals had only recently been appointed to their positions. It was a very good learning experience and I have gained many new ideas on policy, charters, the Education Review Office, property management, staff appraisal etc. and will implement these at the appropriate times.

BOARD OF TRUSTEES: The monthly meeting of the Board will be held at Margaret Anderson's tonight at 7.30pm.

DEFERRED WORKS PROGRAMME: This year's Deferred Works Programme has finally been approved. Three of our twenty-four items of Deferred Maintenance have been approved. These are: replacement of the flooring in the two older classrooms; replacement of the vinyl in the toilets; and replacement of the house's soakpit.

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Third excerpt from THE READ-ALOUD HANDBOOK by JIM TRELEASE

Some parents and teachers, caught up in academics, feel newspapers and magazines are not challenging enough and therefore don't qualify as reading. But why apply different standards to the child than you have. Do you read only the editorial page in a newspaper or do you also read comics, business, theatre, sports and "Dear Abby?" I recall the mother who said to me, "I just don't know what to do with my 13 year old. He hates to read." When I asked what his interests were, she replied, "Sports." But when I suggested a subscription to a sports magazine, she said, "Oh, he already gets "ports Illustrated". He reads it cover to cover."

"Excuse me, but I thought you said he hates to read?" I inquired. The woman looked puzzled for a moment and responded, "Well I didn't think "Sports Illustrated." counted." I quickly explained to her that it did count, that I had read (and saved) every issue of "Sports Illustrated" from the time I was 13 until I was 18 and that was where I first encountered Faulkner, Hemingway, and J.P. Marquand. "A literate person," I said," reads everything. It would help, of course, if occasionally YOU read "Sports Illustrated."

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CROSS COUNTRY: In extremely hot conditions on Tuesday, three of our Standard four pupils competed in the Canterbury Primary Schools Cross Country held at Riccarton Racecourse. In a field of 120 girls (S3-4), Neka Jones was 15th, Sheryl Stephens 35th, and Kelly Pike 58th. This was a very creditable performance by the girls especially since little training was done at school. This result augers well for the running careers of these girls.

TEACHER APPRAISAL WORKSHOP: Next Monday and Tuesday, I am attending a course at the Christchurch College of Education from 9.00am-4.00pm on Teacher Appraisal.

Appendix 2: Comments concerning Lake Forsyth

"Over the years there has been a decline in wildlife, the number of perch, pukekos and so on. This is not good." (local resident)

"It's a good lake. Under-utilized, good for recreation although the weeds are a problem." (local resident)

"We are both proud and ashamed of the lake. Proud of what it is, proud of our uses of it, the flounders and so on. But we are also ashamed of what we have let happen to it." (local resident and farmer on lake's edge)

"I am concerned that the lake is getting worse all the time." (local resident)

"We welcome the lake's existence, but there are many problems with the lake." (local resident)

"The water quality? It's ratshit!" (a rower)

"If water quality was improved it would be a good lake." (fisherman)

"There is potential for great improvements in this area." (Fisherman and resident)

"The lake is in a wind funnel. It is ideal for wind surfing, but the water ... ugh!" (windsurfer)

[the lake has been] "severely mismanaged" Ngai Tahu Trust Board (1986)

"We would welcome any move to improve the condition of the lake and its environs." (Fisherman)