New Zealand as ecosystems

The ecosystem concept as a tool for environmental management and conservation

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Cover: New Zealand ecosystems as a continuum from the sea to mountain tops: looking east to Wanganui River and the Southern Alps from Mt Oneone, South Westland. Photo: Audiovisual Library, Department of Conservation.

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Preface

By publishing this volume, the Department of Conservation is pleased to be associated with Geoff Park's work. Much of the research on which his writing is based was undertaken during the years he was employed with DOC's Science & Research Unit. Nonetheless, the inspiration and energy behind it is his, and he deserves full credit for the result. We have provided support and encouragement throughout Geoff's time with us, to explore this important subject and are proud to document some of his wisdom here.

The book does not represent the official DOC view on all of these matters because that may have constrained debate on a topic that requires a wide array of opinion. Still, we acknowledge the need to take a broad and holistic approach to protection and management of New Zealand's nature, and our own policy and planning systems are evolving accordingly.

The concept of New Zealand as ecosystems helps underpin the vision of the nation's Biodiversity Strategy, our response to the global biodiversity crisis. It also helps establish some of the founding principles for the sustainable management of natural resources in the long term.

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One of the most important alternative suggestions, dating back in essence to Heraclitus, is that the world consists of complex systems of interacting processes varying in their stability. Each such system—of which a human being is one—can survive, like a flame, only so long as it can interact with surrounding systems in particular ways, drawing upon and giving out to the systems around it. It can die by choking on its own wastes or because it has exhausted its resources. That way of looking at the world, which ecological investigations help to substantiate, makes it perfectly plain why 'You can't do one thing at a time'; it destroys, too, the belief that human beings are somehow different, outside the ecosystem, whether as villainous intruders or heroic manipulators. [John Passmore] [1]

[1] John Passmore (1974), 'Man's Responsibility for Nature'. Duckworth, London. 183 p.

Introduction

In conservation programmes throughout the world, there is mounting recognition that the focus on species and their communities, and on protected areas that preclude human use, is not working. Sufficient biodiversity cannot be preserved in perpetuity by reliance only on the protected natural areas that have been set aside from land development. Current trends in many New Zealand ecosystems suggest that, without more ecologically coherent landscapes—greater linkage between natural areas and restoration of natural processes—the margin of insufficiency will only increase in the near future.

Driving this concern is a sea change in ecological theory and science, revitalising the ancient view that holds the life of the world as a myriad of interacting systems, alive and effortlessly self-organising in its own chaotic ways. It recognises that to sustain biodiversity over generations we will need to think beyond places, to processes. We will have to reach beyond the remnant, indigenous patches that so often make up the conservation estate to the integrity of the whole, landscape-sized life-support systems of which they are part.

An expression of this is the emergence of the ecosystem concept in New Zealand's nature conservation and resource management laws. Yet despite the legal requirements to represent ecosystems and protect their intrinsic values, interpretation of the ecosystem concept remains vague and uncertain.

This book explores this new frontier for conservation biology, environmental management and sustainability. It was compiled between 1993 and 1996, at a time of active incorporation of 'ecosystem management' in public policy, notably in the United States and Canada, and consequent active debate on the ecosystem concept and means of depicting ecosystems. It introduces the various means by which New Zealand could be understood and cared for as ecosystems. It recognises that the need for a national ecosystems framework has arisen not only in biodiversity conservation, but also where the linear logic of the law meets the chaos of nature: in the debate on sustainable land management and state-of-the-environment reporting.

Land as ecosystems

Conservationists need some way of identifying kinds of ecosystems—ideally, defined by both biotic and abiotic qualities—that have suffered disproportionate losses since European settlement. These ecosystems would be logical priorities for protection and restoration. [Reed Noss][2]

ECOLOGICAL OPPORTUNITIES FOR MANAGING THE ENVIRONMENT

The maxim of the modern science of ecology, as of the traditional knowledge systems of most nature-based peoples, is that everything is systemically connected to everything else. This inter-relatedness is central to the basic unit of ecology: the *ecosystem*. Humanity has evolved and spread across the earth by dependence on resources wrought from ecosystems. As the stress on ecosystems increases, and global concern about their future sustainability deepens, there is disillusionment among biologists and resource managers about how to approach, operationally, the seemingly overwhelming charge of conserving their biological diversity in the long term. Paralleling this is growing concern at insularity and the explicit, exclusionist misanthropy of many protected area strategies such as New Zealand's[3].

At the heart of this shift is the ecosystem as a unit of resource management. This requires thinking long-term, and beyond protected area boundaries; understanding and managing processes; and taking human ecology seriously without making it the centre of creation or ecologically separate from the rest of life.

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2 Reed Noss (1995), Endangered Species Left Homeless in Sweet Home, Editorial, in *Conservation Biology 9(2)*: 229–231.

3 The Liz Claiborne and Art Ortenberg Foundation, New York (1994) 'The View from Airlie: Community Based Conservation in Perspective'; Deborah Bird Rose (1996), 'Nourishing Terrains: Australian Aboriginal Views of Landscape and Wilderness', Australian Heritage Commission, Canberra.

The new ecology bids us to think beyond the places specially set aside from human activities and the individual species that, world-wide, have been at the centre of the conservation effort, to the wider life-support systems of which both are constituents.

The question is how best to delineate ecosystems, measure them quantitatively and evaluate them qualitatively. Representation of the full range of ecosystems is arguably the most accepted conservation goal world-wide[4]. Conserving their health and integrity is now widely considered to be the best way to sustain biodiversity and prevent species from declining to the point where they require individual attention. Similarly, country-wide, ecosystem-by-ecosystem assessment is considered one of the most effective ways to monitor the state of the national environment.

The ripples of a given land use spread far and wide. Not least of the changes we need to bring to the way we manage our landscapes will be education that helps landowners to see the harm they cause, and judges and tribunals to see how one land parcel is inevitably linked to the next. The key to this will be the framework within which ecosystems are defined. As well as being scientifically valid and relevant to New Zealand landscapes, it must be simple, cost-effective and easily understood.

It will need to integrate non-native and native ecosystem components on public and private land; an ecosystem whose native state has been altered by agriculture will need to be depicted in such a way as to include its pasture and cropland as well as its indigenous forests and wetlands. To assess the rates and trends of change in many of our fragmented, often tiny remains of indigenous ecosystems, it will be crucial to gather information on their primary, pre-settlement ecology.

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[4] Reed Noss (1992), The Wildlands Project, Land Conservation Strategy. *Wild Earth,* Special Issue; Reed Noss and Allen Cooperrider (1995), 'Saving Nature's Legacy', Island Press, Covelo, California.

Part 1. Understanding ecosystems

1. Why have ecosystems become an issue?

The final step, after identifying areas of high biodiversity and protecting as many as possible, is to make connections. Because the protected areas we fashion will never be big enough for some species no matter what the final shape, we must begin linking them with corridors for the movement of animals and the dispersal of plant seeds. With such land bridges, we can transform an archipelago of lonely habitat islands into a functional unit, grand enough to preserve the integrity of an entire ecosystem. [Douglas Chadwick][5]

Environmentalists and land managers, scientists and ecological philosophers are re-appraising how to sustain the elements of wild nature—its species, their genetic variability, communities and habitats, and their ecosystems. They are doing this in landscapes that also need to sustain people and the multitude of material, cultural, spiritual and aesthetic benefits they want. There is emergent agreement that the best approach is to expand the geographic scales of conservation and development programmes to encompass *whole ecosystems*[6].

The evolution of ecology and systems theory has radically altered our understanding of nature and our practice in regard to it. Ecology has emerged as a worldview 'imagining nature as an integrated system, in which each part is only what it is in virtue of its relation to the whole, of which it is a part'[7]. Systems theory, as it comes through ecology,

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5 Douglas Chadwick (1992), Introduction to Hudson, *ed.* 'Landscape Linkages and Biodiversity', Island Press, Covelo, California, p. xxi.

6 Kenton R. Miller (1996), 'Balancing the Scales: Guidelines for Increasing Biodiversity's Chances through Bioregional Management'. World Resources Institute, Washington, D.C.

7 Andrew McLaughlin (1985), Images and Ethics of Nature, *Environmental Ethics 7(4):* 311. Winter.

reveals organisms as conduits of, and configured by, energy. They, in turn, make up myriad, 'thermo-dynamically open systems that are out of equilibrium'[8], each a self-regulating, shifting mosaic in continuous flux but with functional, historical and evolutionary limits.

The result has been a more holistic view of the relationships among plants, animals, and the environment coming to bear on resource agencies. Modern ecological and evolutionary theory show that natural systems are, on the whole, places of adapted fit with many species integrated into long persisting relationships, life perpetually sustained and renewed. There is cycling and re-cycling of energy and materials. The member organisms flourish in their interrelated niches. The system is spontaneously self-organising. There is resistance to, and resilience after, perturbation. The system has integrity. We presume furthermore, that such integrity, already in place, or restored, will continue dynamically into the future[9].

As a nation, we have tended to focus 'conservation' on the *pieces*—the preferred places and indigenous species that protect what is scenic and beautiful, what is rare and unique, and what is representative of New Zealand. But if we are to maintain the country's range of species in perpetuity, we realise we must do more than save a population of each and a small sample of every district's range of plant communities. We must also maintain sufficient of the wider ecological systems of which they are part. As we do, as we find on-the-ground ways to connect one wild, natural area to another, we discover how little we know of how these systems actually function.

A major but more recent influence on the evolution of an ecosystem-based framework for conservation—complemen-

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8 R. Margalef (1981), Stress in Ecosystems: A Future Approach. *In:* G.W. Barrett and R. Rosenberg, *eds*, 'Stress Effects on Natural Ecosystems', pp. 281–289, New York: Wiley.

9 Holmes Rolston (1994), *in*: Foreword to: Laura Westra, 'An Environmental Proposal for Ethics: The Principle of Integrity', Rowman and Littlefield, London.

ted by the 1991 Resource Management Act's recognition of ecosystems as matters of national importance—has been the 1977 Reserves Act's concern with 'the preservation of all classes of natural ecosystems and landscapes'. Its immediate practical outcome, New Zealand's Protected Natural Area Programme (PNAP), would appear, ostensibly, to use the term *ecosystem* to encompass and link many different communities. In practice, however, the programme's primary survey element, the *ecological unit*—a tandem of vegetation type and landform type—has come to equate the terms ecosystem and community; as indeed do many ecological scientists.

As a result, the surveys identify the PNA Programme's primary objective, the best representative sites for protection, their functioning as part of dynamic systems and the ecological processes crucial to maintaining them. This has meant whole ecosystems have in some cases been neglected by PNAP surveys. What is needed is the instilling of a process-based perspective in the programme, at a level of biotic organisation above the community level. In most sand country environments, for example, the range of seral communities involved in a sand dune succession all derive from the same source process: marine sand deposition. Their common origin begs a higher, integrative level in which the concern for conservation and sustainable resource management is as much about process as it is about content.

2. The ecosystem concept

'Forest peoples' [writes Howard T. Odum] 'had religious faith in the forest as a network of gods operating with intelligence. A stable forest actually is a system of compartments with networks, flows and logic circuits that do constitute a system of intelligence beyond that of its individual humans. [Knutson and Suzuki][10]

No ecologist has ever succeeded in isolating an ecosystem in nature, let alone shift one to the safety of an offshore island. As most ecologists freely admit, the concept of the ecosystem is only a metaphor, a human construct imposed upon a much more variable and precarious reality. But it is a very useful one.

While still debated in its definition, as a practical concept the ecosystem has already been widely accepted as a criterion for public policy, from the international scene to the local one[11]. It is a plastic concept—both in scale and perception. Different people looking at the same stretch of country will define differently the ecosystems they believe they see. Agreement is needed on the inevitably subjective criteria for deciding on scale, extent and hierarchy.[12] If the ecosystem concept is to be used, it has to allow for the fact that contemporary ecological theory no longer sees nature as an orderly system in equilibrium; it is instead a patchwork, characterised by pervasive disturbance and instability. Constancy has been replaced by change, chaos and conditions of non-equilibrium[13].

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10 Peter Knutson and David Suzuki (1992), *Wisdom of the Elders*, Allen and Unwin, Sydney.

11 Lynton Caldwell and Kristin Shrader-Frechette (1993), 'Policy for Land: Law and Ethics'. Rowman and Littlefield, Lanham, Maryland.

12 James J. Kay and Eric Schneider (1994), Embracing Complexity: The Challenge of the Ecosystem Approach. *Alternatives 20(3)*: 32–46. Waterloo, Ontario, Canada.

13 Stephen Bocking (1994), Visions of Nature and Society: A History of the Ecosystem Concept. *Alternatives 20(3)*: 12–19.

Even the simplest ecosystems are complex to understand, and our knowledge of how ecosystems function, how they interact with each other and which ecosystems are critical to the services most vital to life on earth is fragmentary[14].

New Zealand's primary ecological survey for biodiversity conservation purposes, the Protected Natural Area Programme (PNAP), exemplifies a dilemma. It defines an ecosystem as any interrelated and functioning assemblage of plants, animals and substrates (including air, water, soil) on any scale, including the processes of energy flow and productivity[15]. In practice, its focus is on the sites in each district that best represent the indigenous, pre-human state of nature, and where the biota pattern is in equilibrium with climate and relatively static when undisturbed.

As the PNAP evolved, it tended to confine the term ecosystem to the ecologically different components of the discrete *natural* areas on which it focused its surveys. There is a distinction however between communities and ecosystems[16]:

- A *community* is an assemblage of populations of plants, animals, bacteria, and fungi that live in an environment and interact with one another, forming together a distinctive living system with its own composition, structure, environment relations, development, and function.
- An *ecosystem* is a community and its environment *treated together as a functional system* of complementary relationships, and transfer and circulation of energy and matter.

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[14] IUCN (1993), 'The Convention on Biological Diversity: An Explanatory Guide'. The World Conservation Union, Environmental Law Centre, Geneva. Draft Text, October.

[15] S.C. Myers, G.N. Park and F.B. Overmars (1987), 'A Guidebook for the Rapid Ecological Survey of Natural Areas', New Zealand Protected Natural Areas Programme, *NZ Biological Resources Centre Publication 6*.

[16] Robert H. Whittaker (1975), 'Communities and Ecosystems', McMillan, 2nd edition.

Both the PNAP's and the World Conservation Union's definition of an ecosystem fit well the manner in which the ecosystem is variously defined:

- The collection of all the organisms and environments in a single location[17].
- Any organisational unit with one or more living entities through which there is a transfer and processing of energy and matter[18].
- A system with biological and physical components interacting through transfers of energy and matter[19].
- A complex of ecological community and environment forming a functioning whole in nature[20, 21].
- An integrated set of biological components making up a biotic community and its abiotic environment; two primary axioms defining ecosystem structure and function are: (1) recycling of essential elements, including biomass in different trophic levels following characteristic spatial and temporal levels in each ecosystem type; and (2) certain emergent properties such as homeostasis and self-regulation are definable and measurable in this highly aggregate unit of study[22].
- A functional unit consisting of organisms (including man) and environmental variables of a specific area[23].

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17 A.G. Tansley (1935), 'The Use and Abuse of Vegetational Concepts and Terms', *Ecology 16*: 284-307.

18 G. Evans (1970), Ecosystems as the Basic Unit in Ecology. *Science 123*: 1127-1128.

19 E.P. Odum (1971), 'Fundamentals of Ecology', 3rd ed. (1st ed. 1953; 2nd ed. 1959), Saunders, Philadelphia.

20 Webster's Dictionary, quoted by George M. Van Dyne in 'Ecosystems, systems ecology, and systems ecologists'. *In:* G.W Cox (1969) 'Readings in Conservation Ecology', Appleton-Century-Crofts, New York.

21 Whittaker, *op. cit.*

22 Peggy L. Fiedler and Subodh K. Jain, *eds* (1992), 'Conservation Biology: The Theory and Practice of Nature Conservation Preservation and Management' (Glossary), Chapman and Hall, New York and London

23 E.V. Bakusis, 'Structural organisation of forest ecosystems', quoted by Van Dyne, in Cox, *op. cit.*

- A volume of land and air plus organic contents extended really over a particular part of the earth's surface for a certain time[24].
- A dynamic complex of plant, animal, fungal, and micro-organism communities and their associated non-living environment interacting as an ecological unit[25].
- All the individuals, species, and populations in a spatially defined area, the interactions among them, and those between the organisms and their abiotic environment[26].
- A physical habitat with an associated assemblage of interacting organisms[27].

Common to all these definitions is the idea that the ecosystem includes the physical or abiotic environment as well as biological components (e.g. organisms) and the assumption that it can operate independent of scale. Some do this from a simple theoretical position. Others are influenced by the principle that, to be useful for land management and administration (in the case of the last two definitions, for biodiversity conservation), ecosystems must be discrete enough to be *mapped*.

Perhaps the greatest value of the ecosystem concept as it has developed to date is the intertwining of two intuitive ideas within it. One is as an ongoing process in terms of energy, materials, seed, pollen, seasonally mobile organisms etc. The other is something integrative in the landscape above species and individuals and the homogeneous communities that species populations form; a level at which

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[24] J.S. Rowe (1961), The level-of-integration concept and ecology. *Ecology 42*: 420–427.

[25] World Resources Institute, The World Conservation Union and United Nations Environment Programme (1992), 'Global Biodiversity Strategy: Guidelines for Action to Save, Study, and Use Earth's Biotic Wealth Sustainably and Equitably.'

[26] G.E. Likens (1995), quoted in V.H. Hayward, *ed.*, 'Global Biodiversity Assessment', United Nations Environment Programme and Cambridge University Press.

[27] Reed Noss (1996), 'Ecosystems as conservation targets', *Trends in TREE 11 (8)*.

new properties emerge, and to which concepts such as health, integrity and sustainability can be meaningfully attached.

2.1 CAN ECOSYSTEMS MERIT THE SAME HUMAN REGARD AS ORGANISMS?

Organisms do not stand on their own; they evolve and exist in the context of ecological systems that confer those properties called life… Biology without its ecology context is dead. [J.S. Rowe][28]

Philosopher Holmes Rolston sees value as sourced by ecology[29]. Recognising that all living things are the product of historically particular systemic forces and are what they are by being located in natural surroundings, he argues that ecosystems are valuable in their own right by highlighting three features:

- Ecosystems are wild in that they are decentred, open, loosely organised, beset by historic contingencies... and empirically entwined with the individuality of each inhabitant.
- Evolutionary ecosystems have, over geological time, steadily increased the number of species on earth to over five million.
- Each stage of evolution has been a liberating development, a freeing of individuals. This liberty allows individuals to move from one ecosystem to another.[30]

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[28] J.S. Rowe (1989), What on Earth is Environment, *The Trumpeter 6*: 123–126, quoted in: Burton V. Barnes (1993), The Landscape Ecosystem Approach and Conservation of Endangered Species. *Endangered Species Update 10 (3&4)*: 13–19.

[29] Holmes Rolston III (1986), 'Philosophy Gone Wild', Prometheus, Buffalo, New York. See also Andrew Brennan (1988), 'Thinking about Nature: An Investigation of Nature, Value and Ecology', University of Georgia Press, Athens GA.

[30] Holmes Rolston (1987), 'Duties to Ecosystems'. *In*: J. Baird Callicott, *ed.* 'Companion to A Sand County Almanac: Interpretive and Critical Essays'. University of Wisconsin Press, Madison, pp. 233–245.

Because of the tens of thousands of member organisms they have generated, continue to support and integrate, ecosystems are, as Rolston says, in some respects more to be admired than their component species. This, of course, is the rationale underlying the International Convention on Biological Diversity (CBD); that the fundamental requirement is the *in situ* conservation of ecosystems and habitats. New Zealand's unique array of ecosystems well fits Rolston's argument.

By admiring species but neglecting their ecosystems, we mislocate our valuing. The CBD notwithstanding, biodiversity conservation programmes commonly channel resources preferentially into single species because the species have become endangered. We procrastinate about ecosystems because of the difficulty in delineating them, or the complex, private ownership of much of their land base. There is a wildness about ecosystems that eludes being completely specified and measured, as it foils prediction. An ecosystem that has regard to the process of succession in which one species pushes another out, for migrating eels or pipiwharauroa (shining cuckoo), or for the water cycle, for example, cannot be given protection status as readily as species and places. But as long as species-centric approaches to conservation continue, we are dealing in half-truths.

2.2 SPECIES OR ECOSYSTEMS AS THE PRIMARY UNIT FOR BIODIVERSITY CONSERVATION?

In the full drama of natural history, identity is a multileveled, dynamic phenomenon. Biological identity... is shared with the fauna and flora of the ecosystemic whole.... Unity is admirable in the organism, but the requisite matrix of its generation is the open plural ecology. [Holmes Rolston][31]

[31] Holmes Rolston (1994), Biophilia, Selfish Genes, Shared Values. *In:* Stephen Kellert and Edward O.Wilson, *eds*, 'The Biophilia Hypothesis', Island Press and Shearwater Books, Washington, DC, and Covelo, California.

'Biodiversity', coined in 1988 to encapsulate the quickening daily loss of plant and animal species across the planet, is defined as the variety of life at genetic, species and ecosystem scales. The signing of the CBD in 1991 has moved the condition of life of the earth to the same level of concern as climate change and world trade. The New Zealand Government has ratified the Convention, and begun implementing a national biodiversity strategy. Yet if the public understand anything of what is meant by the biodiversity of a place, it is its species richness. This is despite the *in situ* requirement for conservation of ecosystems and habitats of the CBD.

How is it that, despite New Zealand's environmental and conservation legislation, ecologists have such difficulty in persuading conservation policy-makers to focus on *threatened ecosystems*? The reasons are manifold:

- An ecosystem approach involves factors beyond the legal boundaries of protected areas and thus expands the political jurisdictions and problems that conservation managers must face. The number of land owners alone generates a greater potential for conflict.
- The ecosystem is widely seen as a difficult ecological concept embracing many uncertainties. Ecosystems seldom have sharp, distinct boundaries. Nor do they change in time in simple, linear and neatly progressive ways. Defining an ecosystem on the ground involves far more arbitrary judgement than is the case with species and communities.
- An ecosystem approach increases the biological complexity conservation managers must face. The simplest ecosystems are complex to understand.
- With scarcely any of New Zealand's ecosystems known in terms of their vital processes, conservation managers realise that attempting to manage any ecosystem means committing funds to something for which they have only a fraction of the necessary understanding.
- Because many of the threatened ecosystems are where many people live, the concept relies too heavily on the

general populace having the ecological knowledge and goodwill to adopt ways that could conserve them. The sympathies and priorities of politicians and conservationist lie elsewhere.

- Many of the invasive introduced animal and plant species that have altered New Zealand's ecosystems from their native state are now too pervasive to make ecosystem conservation feasible.
- Despite possible long-term cost benefits, ecosystem management cannot produce the tangible results of single-species recovery programmes.

But as Holmes Rolston says: no genes, no organism; but also: no ecology, no organism[32]. Both the species and ecosystem levels of organisation are equally necessary.

The species necessity involves co-operation, functional efficiency, and metabolically integrated parts. The ecosystem necessity involves conflict, selection pressure, niche-fittedness, process support. The evidence from the few New Zealand ecosystems that have been examined closely for a sustained period of time[33] is of alarming trends. Without their myriad interactions, species and their member organisms could never have evolved, nor can they remain what they are. Thus, determining the dynamic environmental conditions that species have experienced during their recent evolutionary histories should be as much a foundation of conservation efforts as determining the species' genetic range.

Species need to be seen as essentially one with their habitat; evolving not in isolation from their surroundings, but in constant exchange of energy and matter with them. If *ex situ* conservation is to produce organisms for future

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32 The ideas and argument in this section have been drawn from: Reed Noss (1995), 'Endangered Species Left Homeless in Sweet Home', Editorial, in: *Conservation Biology 9 (2)*: 229–231; Reed F. Noss and Allen Y. Cooperrider (1995), 'Saving Nature's Legacy'. Island Press, Covelo, California; Holmes Rolston (1987), *op. cit*.

33 e.g. Robert Brockie (1992), 'A Living New Zealand Forest'. David Bateman.

release to the wild, as is often argued, it must be paralleled by protection of the natural ecosystem that is their wild context. Ultimately, like single-species inventory, single-species preservation and single-species management become impractical. Sheer numbers of species in some ecosystems illustrates the problem[34] forcing the focus on single species into particular categories:

- Indicator species: particular plants or animals, large charismatic 'endangered' animals, for example, that if actively and selectively saved, will also, along the way, save large slabs of biodiversity.
- Keystone species: plants and animals, the presence of which have effects that ramify through substantial sectors of the community around them and which, if removed may have profound effects on the ecosystem and its capacity to provide services (e.g. bird species such as the New Zealand pigeon, kereru).

In practice, much so-called ecosystem management would be species-orientated anyway. This is because the most sensitive, visible and measurable indicators of ecosystem health and of the barely apparent links that operate between ecosystem components across a landscape are going to be individual species. Many of them will be the large, higher-order species that appeal to the human psyche. The knowledge of their distribution, their population numbers, the historical evidence of the rate of their decline, the factors causing the decline, etc. is vastly superior to that known about New Zealand's equivalent (i.e. threatened) ecosystems.

By 1996, while conservation plans for New Zealand's threatened ecosystems were still in the conceptual classification stages, over 400 of its species were being considered for recovery plans. But as in other parts of the world, many of New Zealand's lower-order species remain unnamed and undescribed. This is the major task before us.

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[34] R.L. Kitching (1994), Biodiversity—Political Responsibilities and Agendas for Research and Conservation, *Pacific Conservation Biology 1*: 279–283.

2.3 THE ECOSYSTEM CONCEPT—MAORI AND WESTERN PERCEPTIONS

The holistic approach of traditional Maori environmental management has much to offer, and is receiving belated recognition of its essential similarity to the ecological approach. [Parliamentary Commissioner for the Environment][35]

*Maori view the environment as a construct of physical (*te taha kikokiko*), mental (*te taha hinengaro*) and spiritual (*te taha wairua*) realities. The same applies of course to ecosystems. Maori see ecosystems beyond the terrestrial site in which an ecosystem might be located. That is, an ecosystem includes the air above, the earth below and the species of flora and fauna within. Further, the physical plane of an ecosystem is contained within and is possessed by corresponding mental (consciousness) and spiritual planes which are larger than the mental plane. Hence the physical plane of an ecosystem becomes the venue or locality in which the identities and entities of consciousness and spirit world may alight and reside...* [Charles Royal][36]

Recently, ecological representativeness has taken conservation beyond the concerns of aesthetics. Yet watershed protection, rare species, the principles of living and non-living components interacting over often vast areas

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[35] Parliamentary Commissioner for the Environment (1996), 'Environmental Management and the Principles of the Treaty of Waitangi: Report on Crown Responses to the Recommendations of the Waitangi Tribunal, 1983–1988', Wellington.

[36] Charles Royal (1993), 'The perspectives of Maori knowledge holders,' in Geoff Park: 'The state of New Zealand's ecosystems: a questionnaire of ecologists, conservation managers, resource planners and iwi kaitiaki' (unpublished). Science & Research Unit, Department of Conservation, Wellington

of the landscape, has been at best peripheral[37]. The future, however, could be different. We have already acknowledged the CBD's *in situ* requirement, the Department of Conservation has signalled its intention to more 'explicitly plan and manage conservation in terms of ecosystems'[38]. Furthermore, the 1991 Resource Management Act has recognised among its primary principles that ecosystems are matters of national importance, and has acknowledged the need to protect their intrinsic values and sustain their 'life-supporting capacity'.

The beauty of ecology is that it seeks to elucidate the infinite inter-relatedness of all things. In spite of analytical/empirical-analytic methods it does contain a metaphysical dimension: a spirituality derived from contemplating the infinite and the continuous, attuned to nature's dynamic cycles and flows.

Before European Christianising influences, Maori creation was one dynamic entity. Land, people, forest, birds, rivers, sea and sky all had a spiritual source in nature gods and other beings. In contrast to the elemental dualism of Christianity[39] at the heart of the Western conservation paradigm, the Maori relationship with nature was a familial one[40]; people as part of nature's systems. This sense of systemic unity endured through fluctuations in tribal occupation and resource possession, but did not prevent many bird species vanishing from New Zealand's ecosystems. Some, like the various moa species, were crucial factors in plant dispersal and ecosystem

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37 The outstanding exception to this has been the Forest Heritage Fund. See M. Harding (1994), 'Implementing Biodiversity Conservation: An Assessment of the Strategic Direction of the Forest Heritage Fund', Wellington.

38 'Conservation 2000: Atawhai Ruamano, discussion document'. DOC, 1993.

39 Clarence J. Glacken (1967), 'Traces on the Rhodian Shore: Nature and Culture in Western Thought from Ancient Times to the End of the 18th Century', University of California Press, Berkeley, Los Angeles.

40 Mere Roberts, Waerete Norman, Nganeko Minhinnick, Del Wihongi and Carmen Kirkwood (1995), Kaitiakitanga: Maori Perspectives on Conservation, *Pacific Conservation Biology 2 (1)*: 7–20.

composition[41]. But as the Maori adjusted to their new land, their old knowledge of nature's rhythms also connected with the mauri, or life force, which through ancient etiquette of guardianship, tapu and reciprocity, ensured survival of iwi Maori. It is this connection that creates disquiet among Maori at the philosophical base of Western protected area strategies.

Some ecologists believe that, where it can, conservation in New Zealand should reflect a pre-human state. They acknowledge that 'to varying degrees, humans are part of every ecosystem'[42]. Yet when New Zealand's protected area legislation refers to 'ecosystems', it is qualified by the term 'natural' and the sense of their 'original', or pre-human state: i.e. that 'which in the aggregate originally gave New Zealand its own recognisable character'[43].

Many of the protected areas that have been created from this conceptual foundation—certainly the plethora of tiny, lowland scenic reserves—were sites of considerable human presence prior to European settlement. With original human inhabitants removed, new human influences upon these sites have become isolated from the flow of the large-scale evolutionary processes that shaped and defined the ecosystem. Either that or they were just too small to be occupied by the territory-hungry keystone species. Such 'nature' does not have an historical, or even ecological precedent. It is our invention.

In its place, the myth of primal, pre-human wildness has created an ecological state that, while seemingly wild and original, has never existed before. Paralleling it is 'a self-loathing environmentalism'[44], as it has been called, that aims

[41] H. Wellman (1994), Hypothesis: Moas's Gizzard Stones and New Zealand Plants, A Geologist's Viewpoint. *NZ Science Review, Vol 51*.

[42] I.A.E. Atkinson (unpublished), 'The Nature of Ecosystems, New Zealand Ecosystems in Particular', paper presented at Department of Conservation forum on ecosystem depiction, April 1995.

[43] Reserves Act 1977, Section 3(b). Government Printer, Wellington.

[44] William Cronon (1995), The Trouble with Wilderness; or, Getting Back to the Wrong Nature. *In*: W. Cronon, *ed*., 'Uncommon Ground: Toward Reinventing Nature', W.W. Norton Co., New York, London.

at 'preserving' the pre-human state on the assumption that modern people can only degrade nature.

Arguing that New Zealand has different nature conservation needs from the rest of the world, some New Zealand environmentalists vigorously oppose any relaxation of the preservation principle. All ecosystems, though, are continually changing in response to influences from both outside and within. Their essence is in their dynamism. Ecosystems cannot, as New Zealand's Reserves Act specifies, be *preserved*. Any attempt to do so, to treat them as static entities, is as unwise as it is unrealistic.

As long as the neighbourhood contains pasture and grazing mammals, nature conservation in New Zealand will continue to need fences. But to keep the remnants long-term in anything like the state they evolved, conservation managers will need different ways of thinking. We need to focus on the processes actually going on: the birds striving to find the surviving bits of their ancient forest; the seeds they don't carry on their flyways, blowing, like the pollen, out of the remnants' trees and away; the constant movement of insects, water (some of it polluted from adjoining farms), nutrients and energy. In such ways the ecosystem concept directs us to what, in the long term, conservation and sustainability are really all about.

With such understanding, however, comes a persistent sense of mystery. As Heraclitus reminds us: 'Nature likes to hide itself'[45]. As parts of nature, we can never grasp the full complexity of her mechanisms. Even the knowledge systems with an empirical base, including theoretical ecology, that embrace the ecosystem concept, are constructions of human thought.

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[45] Lotka's maximum principle. *In*: A.J. Lotka (1956), 'Elements of Mathematical Biology', Dover Publications, New York; quoted in Ingela Wilman (1990), Expecting the Unexpected: Some Ancient Roots to Current Perceptions, *Ambio 19(2)*.

3. Ecosystem management and bioregionalism

Ecosystem management is not just about science, nor is it simply an extension of traditional resource management; it offers a fundamental reframing of how humans may work with nature.... Successful ecosystem management, over time, must nurture both the wildlands at the core of the reserve system and the wildness within human beings. [R.E. Grumbine] [46]

Ecosystem management and bioregionalism seek a shifting relationship with nature that, potentially, pervades all society. It encompasses *whole* ecosystems so as to protect and restore their components sustainably, 'nurturing the mechanisms by which these ecosystems function'[47]. As the bioregionalist Stephanie Mills says: 'The physical circumstances we live in are going to change pretty dramatically with environmental change. If we're going to make humane and convivial responses to those changes... geographical community is going to be a very necessary thing, not just an abstract idea'[48].

Like ecosystem management, bioregionalism is recognition that as well as protected areas from which human use is excluded or in which it is minimised, the safeguarding of

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[46] R.E. Grumbine (1994), What is Ecosystem Management. *Conservation Biology* 8(1): 27–38; quoting Gary Snyder (1990), 'The Practice of the Wild', North Point Press, San Francisco.

[47] A bioregion is 'a geographic space that contains one whole or several nested ecosystems… characterised by its landforms, vegetative cover, human culture and history' (Kenton R. Miller (1996), 'Balancing the Scales: Guidelines for Increasing Biodiversity's Chances through Bioregional Management'. World Resources Institute, Washington, D.C.); 'a region governed by nature not legislature' (Kirkpatrick Sale (1991), 'Dwellers in the Land: The Bioregional Vision', New Society Publishers, Philadephia).

[48] Stephanie Mills (1996), What the World Needs Now, *Utne Reader*, March-April, p. 73.

biodiversity also needs to incorporate the wider landscape. It needs a geographic framework in which to do this, one that acknowledges that nature works on the scale of whole watersheds as well as communities and species.

The notion that sustainability, like the conservation of ecological representativeness, is best addressed in the context of broad geographic domains defined by natural features, has been part of environmental policies since the early 1980s. This is when the country's ecologists created some 68 Ecological Regions and 283 Ecological Districts[49]—the (PNAP). Primarily it was to ensure that New Zealand's protected area network was representative of the ecological diversity of each district.

With the inclusion of Ecological Regions and Districts, in the New Zealand Coastal Policy Statement (1994), as the subdivisions of the country on which the significance of local ecological communities is determined, the concept of bioregion gained the legal standing and authority that would be accepted by the courts.

Both ecosystem management and bioregionalism are more concerned with process than place. In shifting conservation's focus from species and reserves to the balance between *core* reserves, buffers and the matrix of land used intensively by humans, they expand the scales of space, time and inclusiveness beyond the current norm. They also require resource managers to interact more with each other and those people who inhabit the ecosystems of concern.

The defining characteristic of ecosystem and bioregional management is co-operation and co-ordination between those who live in or own land in an ecosystem, have management or stewardship responsibilities within it, and knowledge and information about it. It represents a longer time-frame defined by ecological boundaries that are regionally rather than locally significant. The 1995 overview

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[49] W.M. McEwen (1987), Ecological Regions and Districts of New Zealand, 3rd ed. Biological Resources Centre, DOC, Wellington (4 volumes).

report by the US Interagency Ecosystem Management Task Force, 'The Ecosystem Approach: Healthy Ecosystems and Sustainable Economics', sets out the common guiding principles:

- Develop a shared vision of the desired ecosystem condition that takes into account existing social and economic conditions in the ecosystem, and identify ways in which all parties can contribute to, and benefit from, achieving ecosystem goals.
- Develop co-ordinated approaches among agencies to accomplish ecosystem objectives, collaborating on a continuous basis with local and tribal authorities, and other stakeholders to address mutual concerns.
- Use ecological approaches that restore or maintain the biological diversity and sustainability of the ecosystem.
- Support actions that incorporate sustained economic, socio-cultural, and community goals.
- Respect and ensure private property rights and work with private landowners to accomplish shared goals.
- Recognise that ecosystems and institutions are complex, dynamic, characteristically heterogeneous over space and time, and constantly changing.
- Use an integrative approach to management to achieve both desired goals and a new understanding of ecosystems.
- Integrate the best science available into the decision-making process, while continuing scientific research to improve the knowledge base.
- Establish baseline conditions for ecosystem functioning and sustainability against which change can be measured; monitor and evaluate actions to determine if goals and objectives are being achieved.

4. Intrinsic and impacted: biodiversity conservation and resource management

The birds still strive towards the ancient forest, and the pollen and seeds that they don't carry on their flyways still blow out of the trees and away—even though in vain. The water from the mountains still strives towards the sea, as insistently as the dunes strive inland. [Geoff Park][50]

As nature is put increasingly under stress, the conservation of natural areas is being justified in terms of maintaining ecosystem integrity. World-wide, it is leading conservation biologists, policymakers and managers to re-examine their programmes; to look not only at the indigenous species and natural areas they inhabit, but beyond them to the life-support system of which they are part:

1. The processes governing the system.
2. The context in which it is embedded.
3. The historical range of flux.
4. The evolutionary and physiological limits of the organismal components.
5. The nature and impact of episodic and long-term phenomena, including the roles of people in the past and present.[51]

A true ecosystem-based approach to biodiversity conservation is as much concerned with ensuring the life-support processes that create and sustain the bioregion's

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50 Geoff Park (1993), Lines on the Living Landscape: Nature's Regional Counsel. *Terra Nova 6*: 44–45.

51 Steward T.A. Pickett, V. Thomas Parker and Peggy L. Fielder (1992), The New Paradigm in Ecology: Implications for Conservation Biology above the Species Level, *In:* Peggy L. Fiedler and Subodh H. Jain, *eds*, 'Conservation Biology: The Theory and Practice of Nature Conservation Preservation and Management'. Chapman and Hall, New York and London.

particular range of species and their communities, as it is with these *per se*.

It complements community-based conservation by recognising key ecosystem processes, by highlighting areas that maximise continuity across a range of communities, and in bioregions where the indigenous ecological pattern is fragmented, by allowing for potential connectivity. The aims of the Protected National Area Programme (PNAP) need to be bolstered to accommodate this.

Four such goals against which success or failure can be gauged prevail in the international ecological literature:

- Protect representative examples of all native ecosystem types across the natural range of variation.
- Maintain evolutionary and ecological processes (e.g. disturbance regimes, nutrient cycles).
- Maintain viable populations of all native species.
- Manage landscapes and species to be responsive to both short-term and long-term environmental change; accommodating human activities within these constraints.

The key to it all is how, and at what scales, to operate the ecosystem concept on the ground, in a geographic or spatial framework that enables each ecosystem's human inhabitants to recognise and understand it, and in which its integrity and health can be evaluated.

4.1 A LAND OF LITTLE LANDSCAPES: ECOLOGICAL STRUCTURE AS A BASIS FOR ECOSYSTEM RECOGNITION

… an ecology 70 million years separate from other continental land masses. This is the truly unique thing about being a New Zealander. We are the only people in the world face to face with plants and animals with which we are not, in any time frame we can comprehend, co-

evolved… If ever there was a land where people are not the way their land is, this is it… [Simon Upton][52]

New Zealand has no simple sameness. Its primal forces have articulated themselves in a pattern of mountains and plains, coasts, lakes and rivers as complex as it is dynamic.

Its pronounced and geologically active physical character has had substantial recognition in the national 'bioregional' framework aimed at identifying the full range of New Zealand's ecological layout and improving the extent to which the national network of protected areas represents it[53].

An ecological district, like other forms of bioregion[54], is a stretch of country where geological, topographic, climatic and biological features and processes, including the broad cultural pattern, interrelate to produce a characteristic landscape and unique range of biological communities. Most 'ecological districts' are delineated by a major change in the regional ecology, inevitably in the land's physical form. Thus the steep greywacke hills of the Cook Strait coast north of Wellington are distinguished from the adjoining sand country and alluvial plains of the Horowhenua. Other districts show change as a gradual continuum. The land's physical form was also used in the

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52 Simon Upton (1996), Making it all irreversibly ours. *New Zealand Books 6:* 224–225.

53 P. Simpson comp. (1982), 'Ecological Regions and Districts: A Natural subdivision of New Zealand.' Wellington, NZ Biological Resources Centre, DSIR; G.C. Kelly and G.N. Park (1987) 'The New Zealand Protected Natural Areas Programme: A Scientific Focus'. *Biological Resources Centre Publication 4*, DSIR, Wellington; W.M. McEwen, *ed.* (1987), 'Ecological Regions and Districts of New Zealand', 3rd edition (a four-part series of maps and information booklets). NZ Biological Resources Centre, Department of Conservation, Wellington.

54 Peter Berg and Raymond Dasmann (1978), Reinhabiting California. *In:* P. Berg, *ed.*, 'Reinhabiting a Separate Country: A Bioregional Anthology of Northern California'. Planet Drum Foundation, San Francisco; Kirkpatrick Sale (1991), 'Dwellers in the Land: The Bioregional Vision', New Society Publishers, Philadephia; Kenton R. Miller (1996), 'Balancing the Scales: Guidelines for Increasing Biodiversity's Chances through Bioregional Management', World Resources Institute, Washington, D.C.

same conservation programmes, 'in-tandem' with mappable homogenous vegetation types, as the ecological unit. It was also used in the survey reconnaissance phase at a level between the ecological unit and the ecological district: as the 'land system'.

In summary, this is a complex of bioregional patterning developed in evolutionary isolation from the rest of the world, with the consequent high level of endemism in its biota. As a defining feature of New Zealand, conservation programmes need to do justice to it. But it seems to be adequately enough dealt with by the network of ecological districts—or does there need to be an active operational level, such as the land system, between the ecological unit and the ecological district? Some PNAP surveys have indeed activated the land system concept[55].

Types of land defined by thresholds in the physical environment—hills differentiated from river terraces, from coastal sand landforms, and so on—certainly enable a division of the country into ecosystem surrogates that its inhabitants or those making decisions that affect their health and integrity, can readily recognise. But ecologists are drawn beyond this to particular, keystone living components such as kereru feeding over many kilometre-wide zones, or seabirds like petrels drawn inland for parts of their life or season. They may have quite a different ecosystem in mind. Whatever the system's framework that creates the boundaries, some processes vital to life-support are moving materials and energy *across* them.

4.2 SEVERED CONNECTIONS: HUMAN IMPACTS ON INDIGENOUS ECOSYSTEMS

When the Maoris landed, they found an intact New Zealand biota… a scene as close as we will ever get to what we might see if we could reach another fertile planet on which life had evolved. Within a short time, much of

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[55] S. Courtenay and Joseph Arand (1992), 'PNA Survey of Balaclava, Sedgemere and Dillon Ecological Districts'.

that community had collapsed in a biological holocaust, and some of the remaining community collapsed in a second holocaust following the arrival of Europeans… A few centuries of hunting had sufficed to end millions of years of moa history. [Jared Diamond][56]

In *ecosystem* terms, by the first half of the nineteenth century New Zealand was very different from what we experience today. But without almost half of its bird species it was already an acutely altered ecological system. Indeed New Zealand is also widely considered to be unparalleled in the degree of change that humanity has brought[57]. Those changes, perhaps unparalleled anywhere, have rendered New Zealand, with Hawaii, among the nations with the greatest proportion of their native species endangered, or at risk. That is, some 315 of its 2700 vascular plant species, 30% of its reptiles, 50% of its birds and 25% of its freshwater insect species.

Even greater than this has been the change to the 'ecosystem integrity'. Protected areas, say those under New Zealand's 1977 Reserve Act, are supposed to 'preserve representative samples' of the ecosystems which 'originally gave New Zealand its own recognisable character'. Implicit is the principle of reaching, as far as possible, for the state of nature before human disturbance. There is no inhabitory place for humans, nor a material resource for their use. We actively exclude ourselves in an endeavour to create and see for ourselves a New Zealand as it might have been like before us. This is despite the fact that for centuries before preservation, many of these same protected areas were crucial resource areas for people. And as surrounding land uses have isolated the protected area from the flow of its ecosystem's large-scale processes, many other species—in some cases, its keystone ones—have left it.

[56] Jared Diamond (1991), 'The Rise and Fall of the Third Chimpanzee', Vintage, London.

[57] Alfred C. Crosby (1986). 'Ecological Imperialism: The Biological Expansion of Europe 900–1900'. Studies in Environment and History, Cambridge University Press.

It has been estimated[58] that since the arrival of humans and the Asian rat (kiore), some 40% of the bird species originally present in northern coastal forests have become extinct. With them, of course, went a host of intricately evolved inter-species relationships. This must have had enormous consequences in ecosystem function such as pollen and seed dispersal. Scientific reconstruction of pre-human New Zealand's lowland and coastal forest-bird systems identifies 10 feeding guilds differentiated by feeding level in the forest, feeding sites and food eaten. As Charles Darwin observed in Galapagos finches, these guilds facilitated co-existence of species within guilds. The herbivores of the ground-feeding and arboreal guilds are considered to have no counterparts elsewhere in the world.

Beginning with the explorer James Cook's deliberate introductions of 'better plants' and animals in the 1770s, a host of foreign species began entering the country and transforming its ecosystems. From virtually no pakeha in the country in 1830, within less than a settler's lifetime, there were over half a million involved in creating a Britain of the South. In many regions, entire classes of land rapidly became dominated by exotic species with only relict natural areas remaining. In terms of ecosystem integrity and function, the repercussions of this metamorphosis are still emerging.

In most of the world's ecosystems, the diversity of species increases as one descends altitudinally towards the coastal lowlands[59]. The few studies that have been done on New Zealand birds show a greater number of species on coastal plains, valley floors and lower slopes than on upper slopes and tops. The lowland parts of the New Zealand ecosystem, are those to which European settlement and agriculture have been attracted. From here indigenous species have largely vanished. So extensive is the fragmentation that the ecosystem's resilience—its ability to recover from and

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58 I.A.E. Atkinson and P.H. Millener (1991), An Ornithological Glimpse into New Zealand's Pre-human Past. *In: Acta XX Congressus Internationalis Ornithologici, Wellington NZ Vol. 1*: 127–192.

59 Robert Brockie (1992), 'A Living New Zealand Forest'. David Bateman.

absorb disturbances—and its capacity to ever again reorganise into similar ecosystems, may be lost. The fragments of natural ecosystems in the productive lowland and coastal zones that do survive protected—the remnant forests and wetlands, dune, riverine and freshwater ecosystems that are considered to be New Zealand's *threatened ecosystems*—were set aside from development largely for scenery purposes.

New Zealand's protected area system was not for protection of biodiversity, ecological integrity and evolutionary processes. The few areas where it contains greater than 1000 ha—only 3% of the total number of protected areas—were mainly set aside as timber reserves or to secure the water catchments of the productive lowlands from erosion and for recreation. Ninety-two percent of New Zealand's protected areas make up, in total, merely 1.0% of the national land area in conservation tenure. Seventy-five percent are less than 50 ha in area, 30% less than 1 ha. These are too small, too isolated and representing too few types of native ecosystem to perpetuate the country's biological diversity. The elimination of the major indigenous herbivorous and carnivorous species and the introduction of non-indigenous ones means no New Zealand ecosystem is in, or can approach, the pristine condition. Furthermore, to varying degrees, people are now part of every ecosystem.

Some New Zealand ecosystems have, however, proved resilient to human influences. Others have proved extremely vulnerable. This contrast can commonly be experienced *within* the one ecosystem: some components utilised to the virtual ousting of the native biota, others still in their essentially indigenous state.

Most ecological opinion advises the landscape scale, rather than the community scale, is to be the level at which ecosystem management to maintain essential processes in a healthy state might best occur. If so, these different situations must be allowed for. Ideally, the national and regional frameworks established to depict, delineate and evaluate the state of biodiversity and ecosystem health should accommodate rather than avoid or obscure them.

Part 2. Ecosystems as planning and management units in New Zealand's landscapes

5. Seeing the indefinite—New Zealand as ecosystems

The best conservation strategy lies in a synthesis organised around the central concept of ecology: the ecosystem.... To be useful to conservationists, defined ecosystems must be discrete enough to be mapped. They must also be describable by adjectives denoting quality. [Reed Noss][60]

Like science, like species, habitats and communities, ecosystems lie at the interface between the abstract constructions of our minds and the phenomena of the external world[61]. New Zealanders and their landscapes are now subject to laws that have regard for the interdependence and coherence of ecosystem ecology. In the coastal environment, for example, once a legal no-man's land between territorial and marine authorities, it is now national policy to protect ecosystem 'integrity, functioning and resilience in terms of... the dynamic processes and features arising from the natural movement of sediments, water and air'[62]. Much of what the Resource Management Act (RMA) and the New Zealand Coastal Policy Statement term the 'natural character' of the coast is a product of a once-forested land meeting the sea; 'the myriad, unownable processes that nourish an estuary and keep it healthy'[63].

As the focus moves from representing the range of nature's ecological diversity to 'holding the line on damage to

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60 Reed F. Noss (1996), Ecosystems as conservation targets. *Trends in Ecology and Evolution 11(8).*

61 R.H. Peters (1991), 'A Critique for Ecology', Cambridge University Press.

62 Department of Conservation (1994), 'New Zealand Coastal Policy Statement 1994'. Issued by notice in the *New Zealand Gazette*, 5 May.

63 Geoff Park (1995), 'Nga Uruora: The Groves of Life. Ecology and History in a New Zealand landscape', p. 264. Victoria University Press, Wellington.

ecological processes'[64], New Zealand is increasingly seen as *ecosystems*—diverse, interacting and constantly changing. With 'landscape', 'ecosystem' has become commonly used to set the context for biodiversity protection and state-of-the-environment monitoring alike[65]. The term 'ecosystem' conveys the idea that as much as conserving biodiversity and environmental health is about species and habitats, it is about the ecological linkages and processes that connect them. The term 'landscape' enables people to see the mobility of ecosystems in time and space as well as the interacting relationships between them.

Consequently, both the landscape and ecosystem concepts have an active expression in New Zealand's environmental legislation. They are commonly incorporated as general, organising concepts in biodiversity conservation and environmental management programmes. The conceptual base of 'landscape ecology'[66] is driven by the principle of ecological sustainability at the landscape level; and in terms of ecosystem integrity, form, function and resilience, and the delivery of tools that can:

- Articulate through resource inventories and statutory advocacy procedures, holistic concepts of ecosystem depiction which cross tenure boundaries.
- Distinguish one ecosystem from another and insert more forcefully into the geographic information systems used for planning purposes, the ecological processes that, along with their biotic composition, are the basis for their distinction.

The ecosystem concept is in New Zealand's legislation because of the need of the country's environmentalists and

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64 Ministry for the Environment (1994), 'Environment 2010 Strategy', Wellington.

65 Paul G. Risser, James R. Karr and Richard T.T. Forman (1984), Landscape Ecology: Directions and Approaches. *Illinois Natural History Survey Special Publication 2.* Champaigne, Illinois.

66 Landscape ecology is sensitive to the heterogeneity of the landscape and land-use patterns: R.T.T. Forman and M. Godron (1986), '*Landscape Ecology*'. John Wiley & Sons, New York.

natural resource managers to answer the key question of resource sustainability, '*What is the environmental bottom line here*?' Both the RMA and the CBD require managers to assess the state of our natural capital. They need something else above those levels of organisation in the landscape that can't be explained simply from a tally of its component species and communities:

- Something that can gauge and express the degree of coherence, or lack of it, between core conservation areas, and between them and the matrix of lands used more intensively by humans.
- Something about its integrity, health and sustainability as a life-support system that can't be inferred from species and their communities.
- Something that requires them to have regard not just for what is there today, but for what it used to be in its original, indigenous state (*history)*; and what, if restored, it could be again in future (*potential*).
- Something that enables them to see the *trend* of its changing in time, whether depleting or stable, collapsing or regenerating.

Above all, they know from their information requirements and the nature of geographic information systems, the need to express this organisational level as a reality in the form of mapping units. They have to be able to bring the human processes in a landscape alongside those of its other species, as dependent and integral parts of a common system; in ways that lead people to understand what has happened in it historically, how it is trending at present, and how it leads to a sustainable future.

The fact that the ecosystem concept can be applied at different scales—and that particular features of ecosystems can be used to identify, name, describe and delineate them, and give them value—lends it to the wide spectrum of conservation problems. Flexibility is fine, as long as you make explicit your purpose for doing so. But generally there is still poor scientific *knowledge* of ecosystems.

Nevertheless, when New Zealand ecologists are asked to consider ecosystems for purposes of biodiversity conservation, there is a high level of consensus that biodiversity conservation should be more ecosystem-based. It is also apparent that when they classify ecosystems and identify the ones whose health and continued existence they are most worried about, they do so mainly at the organisational level above the community. Coastal sands are frequently cited, for example, as an *integrative* name for the many distinct community types differentiated by a complex of states and processes.

If conservation plans are to recognise ecosystems as biodiversity assets, to prioritise and compare them, and gauge success, then ecosystems must, like species, be definable and measurable. They must be able to be 'classified at some hierarchical level and delineated on a map', as the US survey of endangered ecosystems puts it.

It must be realised that there is no one right way of observing the natural world and measuring the impact of human development upon it[67]. Related to this is the vexed problem of boundary definition: 'what sometimes appear to be obvious boundaries for delineating a particular ecosystem may have little significance for processes operating across those boundaries'[68].

An ecosystem boundary should be readily apparent when it is crossed. As Atkinson says, deciding on boundaries is the first step for an ecologist studying an ecosystem. Odum emphasised that while the ecosystem was a whole greater than the sum of its parts and had emergent properties, ecosystems are not entities that can be unambiguously defined and delineated; they are defined by the needs of the

67 Karen J. Warren and Jim Cheney (1993), Ecosystem Ecology and Metaphysical Ecology: A Case Study. *Environmental Ethics 15:* 97–116.

68 I.A.E. Atkinson (unpublished), 'The Nature of Ecosystems, New Zealand Ecosystems in Particular', paper presented at Department of Conservation forum on ecosystem depiction, April 1995.

investigator[69]. For the inventories of ecosystems that biodiversity conservation programmes require, an eco-system needs to be recognisable as a functional entity with internal homeostasis and recognisable relationships between components. It must also have identifiable boundaries[70].

But even if our purpose is clear, can we actually subdivide a stretch of country to distinguish large-scale ecological differences within it, delineate the units on maps and call the map units ecosystems? 'Ecological boundaries', a recent US survey says, are one of the highest agreed themes 'critical to definition, implementation, or overall comprehension'[71]. Nevertheless, the question continues to be asked[72].

The International Convention on Biological Diversity (CBD)'s fundamental requirement for the *in situ* conservation of ecosystems and habitats speaks of an ecosystem as the individuals, species, populations and the interactions between them and their abiotic environment '*in a defined area*'[73]. It assumes, in other words, boundaries. Just as resource management depends on mapping or otherwise making tangible its targets, so does biodiversity assessment. *What* a thing (a species, community, population, river, person, etc.) is, is at least partly a function of its geographic context: *where* it is, i.e. a function of the relationships in which it stands in relation to other things and to its history, including its evolutionary

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69 E.P. Odum (1971), 'Fundamentals of Ecology', 3rd ed. (1st ed. 1953; 2nd ed. 1959). Saunders, Philadelphia.

70 D. Reichle and S. Auerbach (1979), 'Analysis of Ecosystems'. *In:* H. Shugart, R. O'Neill, P.A. Stroudsberg: 'Systems Ecology'. American Institute of Biological Sciences, New York.

71 R. Edward Grumbine (1993), What is Ecosystem Management? *Conservation Biology 8(1)*: 27-38.

72 Ian Spellerberg (1996), What of Biological Diversity? NZ Dragging its Feet over International Convention. *New Zealand Herald*, October 23.

73 G.E. Likens (1995). *In:* 'Global Biodiversity Assessment', United Nations Environment Programme and Cambridge University Press.

history[74], and its boundaries. Resource managers need to operate on the basis of ecosystems and enable their public to 'act with a high level of awareness of… their actions on ecosystems'. This requires both to see what constitutes these boundaries, these limits, on the ground, to push up against them and feel sure they are there.

If we are to conserve a stretch of country's biodiversity, sustain its natural life-support systems and report on the state of its environments, we need much more than that. We need information on its ecological layout; how those life support systems lie in the landscape, their different dynamics and their interactions with each another. Such questions lead to the idea that meaningful comparison needs to be made at the organisational level above species and their communities. Just as inevitably they bring the questions as to where to draw the boundary lines. Added to this is the increasingly active presence of the ecosystem concept in legislation and policy, and the assumption that ecosystems are *spatial* units we can expect to see on maps.

The difficulties are well summed-up by the UN Environment Programme. 'A pragmatic approach… to obtain some measure of ecological diversity between areas', as it calls it, should recognise certain key principles[75]:

1. There is nothing equivalent to the species concept that can provide a fundamental criterion for defining ecological units (ecosystems, for example). This simple but important conclusion has profound implications for ecology.
2. It follows from (1) that there is no single form of classification that we can regard as natural and which provides the ideal towards which we can aim. Classifications based on very different criteria (ecosystem properties, etc.) are all equally justifiable.

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[74] Warren and Cheney (1993), *ibid*.

[75] United Nations Environment Programme (1995), 'Global Biodiversity Assessment'. Cambridge University Press.

3. The boundaries drawn between ecological units are necessarily arbitrary.

Atkinson echoes point (3), stating that we should not confuse the ecosystem management need for defining and depicting ecosystems with attempts to classify them. Other prerequisites that need to be considered before subdividing a stretch of country into ecosystems are[76]:

- The chosen method should highlight and facilitate the continuity of process between ecosystems. Without it, we have no sound basis for attempting to manage ecosystems.
- It should acknowledge that, to varying degrees, and despite their recent settlement of New Zealand, humans are part of every ecosystem.
- The subdivision should be widely understandable to New Zealanders.
- We must think carefully about the most useful scale at which to subdivide ecosystems.

Since the emergence of the ecosystem concept in New Zealand legislation, its potential has been expressed in two parallel areas of public policy. These are the 1992 CBD, to which New Zealand is a signatory, and the Resource Management Act 1991. The latter establishes the 'higher order' *purposes* of resource management in New Zealand as 'safeguarding the life-supporting capacity of air, water, soil, and ecosystems'; defining 'environment' as primarily 'ecosystems and their constituent parts…'; and the protection of the 'intrinsic values of ecosystems' as one of its principles.

This chapter first reviews the legislative and policy areas in which the ecosystem concept has significance. Then, it sets out the key concepts for interpreting and evaluating New Zealand as ecosystems at the landscape scale and some practical tools for the task.

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[76] I.A.E. Atkinson, *op. cit*.

5.1 BIODIVERSITY CONSERVATION: THE CONSERVATION ESTATE AND ITS ECOSYSTEMS

… what we see now is the culmination of fragile processes which (for all practical purposes) can never be repeated.
[Geoff Kelly][77]

Fundamental to safeguarding the world's myriad plants and animals[78], the CBD is pertinent to the New Zealand situation. The Convention calls on the world's nations to identify and monitor ecosystems that: contain high diversity, large numbers of endemic or threatened species, or wilderness; are required by migratory species; are of social, economic, cultural or scientific importance; are representative, unique or associated with key evolutionary or other biological processes.[79]

There had been earlier developments. In 1977 a legislative requirement to preserve 'representative samples of natural ecosystems and landscapes'[80] followed in 1986 by a sound bioregional framework within which to operate it[81]. Together they lead an evolution in conservation philosophy towards greater incorporation of nature's systemic coherence across landscapes, of nutrient flows, and the dynamics of weed and pest species. Conservation practice was nonetheless still prevailed upon by foci on individual species and places.

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77 G.C. Kelly (1980), Landscape and Nature Conservation. *In:* L.F. Molloy (comp.), 'Land Alone Endures: Land Use and the Role of Research', DSIR, Wellington.

78 IUCN (1993), 'The Convention on Biological Diversity: An Explanatory Guide', Preamble. The IUCN Environmental Law Centre, draft text, Bonn, Germany.

79 IUCN (1993) *op. cit.* Annex 1: Identification and Monitoring.

80 Reserves Act, 1977; section 3(b); G.C. Kelly and G.N. Park (1986) 'The New Zealand Protected Natural Areas Programme: A Scientific Focus.' *NZ Biological Resources Centre Publication 4*. DSIR, Wellington.

81 W. Mary McEwen, *ed*. (1987), 'Ecological Regions and Districts of New Zealand', 3rd edition (a four-part series of maps and information booklets). NZ Biological Resources Centre, DOC, Wellington.

To create a national biodiversity strategy, the Department of Conservation decided on a shift in emphasis in its work, moving to manage conservation on an ecosystems basis, regardless of fixed-term tenure or ownership[82].

The first level of debate on a national biodiversity strategy:

- Acknowledged the importance of earth science knowledge to ecosystem understanding: a growing awareness that seemingly unrelated disciplines such as landforms, hydrology, climate and soils intersect and influence ecosystem processes.
- Recognised the compelling logic of an ecosystem approach to sustain biological diversity and productivity, and its prominence in the Resource Management Act now directing national, regional and local authorities to do so.
- Recognised the need be able to look at *every kind of land* as part, at least, of an ecosystem, assess what remains of the indigenous life that nature intended for it and what potential there might be for its recovery.

An analysis of biodiversity conservation practice shows that it is essentially either the mitigation of threats to conservation 'assets' when operating in rearguard action, or initiating or stimulating a process for enhancement[83]. Management action at specific places produces an expected outcome directed at an ecological *process*. It was on analysis of threats to a process that the requirement for an organisational and operational level wider than species became obvious. That being the case, biodiversity conservation requires its assets classification at three levels[84]:

1. *Elements* involving single species, such as the kokako.

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[82] 'Conservation 2000: Atawhai Ruamano, discussion document'. Department of Conservation (1993).

[83] Malcolm Harrison (unpublished), National 'Ecosystem' Mapping for Conservation. Paper presented at AURISA/SIRC'95, 7th Colloquium of the Spatial Information Research Centre, University of Otago, April, 1995.

[84] *ibid.*

2. *Units* involving communities which can be readily identified and located, such as a flax-raupo swamp from the kahikatea-pukatea forest alongside it.
3. *Something less tangible, but which addresses processes, connectivity, and intactness at the landscape scale.*

One of the ecosystem concept's great advantages, it recognised, is that it enables comparison of very different stretches of country with totally different species compositions; with many species or with few; with a close, intricate pattern of communities or a broad, simple one. Level 3 is clearly about ecosystems.

As important to ecosystem-based biodiversity conservation as on-the-ground depiction and delineation of ecosystems was, the group argued, the *evaluation* of ecosystems in ways that reflect their dynamics. A range of criteria, drawn from the international literature were examined and tested[85]:

- *An historical profile of the ecosystem—its indigenous state prior to the arrival and spread of alien species; episodic phenomena shaping it; major factors altering it since settlement; prevailing rate of change.*
- *Present-day ecological state—area (in indigenous state, protected); representativeness; intactness; connectivity; diversity of species and communities.*
- *Potential and sustainability—viability; resilience; sustainability of natural water regimes, nutrient cycles and energy flows; restoration capabilities and needs; potential to maintain ecological integrity through major natural episodic events.*

The working group also recognised the need for quality control to maintain comparability across the country. In so doing, it was influenced by a principle emergent from the Australian biodiversity debate: *'no part* [of Australia] *should*

85 Criteria from trial field card for ecosystem evaluation within revised Protected Natural Area Programme surveys, compiled by G.N. Park, November 1994, following DOC working group on Biodiversity priority setting system.

be viewed as unimportant to the conservation of biological diversity. While much attention focuses on the species or genetic level of biodiversity, management must occur at the pattern and process level, i.e. the landscape'[86].

A Department of Conservation study then outlined a Biodiversity Action Plan identifying the ecosystem as a Focus of Action. Integrated management of *whole ecosystems,* it argued, was a fundamental conservation and resource management objective for New Zealand. However, the lack of an accepted New Zealand-wide framework for ecosystem definition and depiction, and an inability to utilise ecosystem concepts in management, was a serious blockage to ecosystem-based conservation and sustainable management. To facilitate it, the following are needed[87]:

- Tools to classify and identify New Zealand ecosystems and to produce maps.
- Audits of each ecosystem to identify its current biodiversity status, sustainability and goals for management.
- Revised quantified listings of ecosystems at risk and prioritised ecosystems for restoration actions.
- Use of ecosystems as units for planning and state-of-the-environment reporting.
- Identification and incorporation into Resource Management Act plans and policies, ecosystem-based 'environmental bottom lines' and the importance of ecosystem-wide processes.

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86 Prime Minister's Science Council (1992), 'Scientific Aspects of Major Environmental Issues: Biodiversity.' Australian Government Publishing Service, Canberra, p.11. See also D.W. Walton, M.A. Forbes, J.R. Busby, and Jean Just (1992), Biological Diversity and the Essentiality for a National Nature Conservation Reserve System for Australia, *In:* 'Biodiversity—Broadening the Debate. Australian National Parks and Wildlife Service, Canberra, pp. 17–24.

87 G.H. Campbell (1996), 'Towards a Biodiversity Action Plan for the Department of Conservation', June.

5.2 INTEGRATED RESOURCE MANAGEMENT, SUSTAINABILITY AND STATE-OF-THE-ENVIRONMENT REPORTING

New Zealand's Resource Management Act 1991 (RMA) has been called an Aotearoan response to developing global imperatives[88]. It is reformist legislation, making the sustainability of the resource now the driving force in determining the use of land. Its purpose is to mediate between human uses of resources and the needs of the ecological systems that created the resource base in the first place; to ensure that while society's well-being is dependent on at least some use and alteration of nature, neither the life-supporting capacity of air, soil, water and ecosystems nor the needs of future generations are compromised.

The RMA strikes a deliberate tension between sustainability and the public interest on one side, and the private individual's self-interest and rights on the other. It is reflected in the mix of market and no-market resource mechanisms anticipated by the Act. Like the Act's 'vague', 'confusing'[89] interpretation of key sustainability concepts like the ecosystem, it is intended to be worked out through regional and local plans.[90] As its purpose and principles say it is, the RMA's concern is with the sustainability of ecosystems so as to provide for long-term human development, and it is willing to set biophysical limits, or 'bottom lines', to human use of natural systems. The

88 Simon Smale (unpublished), 'Scenic Aesthetics and Sacred Cows', Department of Conservation, lecture 1996.

89 B.V. Harris (1993), Sustainable Management as an Express Purpose of Environmental Legislation. *Otago Law Review 8(1)*: 51–76.

90 Graeme Campbell (unpublished), 'Perspectives on DOC and the Resource Management Act: Four Thinkpieces', 10 June 1996.

approach taken to gauge those limits should have, therefore, an explicitly ecological starting point[91].

By its reference to ecosystem integrity, form, functioning and resilience[92] factors, the RMA necessitates a long-term, *systems* approach to resource management. In response to this concern of the RMA with what is right *systemically* for any particular ecosystem, professionals in resource management are recognising that 'to work effectively with the RMA and its purpose of sustainable management, we need to align ourselves with a landscape-as-system interpretation'[93].

Modern ecosystem ecology's demonstration of the ubiquity of trans-boundary effects—that groundwater, like pollen, flows; birds carrying seed across the landscape regardless of who owns the human subdivision of it—undercut the assumptions about land on which much of modern New Zealand is built. That is, that much land has been privatised to a level of perceived absolute ownership.

By contrast, the RMA is substantially *about* ecosystems. The concept is right up front, in an active sense, in its 'Purpose

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[91] i.e. for many of New Zealand's lowland ecosystems, the state they were in when European settlement and its immigrant biota began the processes of ecosystem fragmentation and decay. There are problems though in closing a definition by proximity to a particular historical date.

[92] See RMA interpretation of 'intrinsic values, in relation to ecosystems'.

[93] Simon Smale (1994), 'Landscape and the Resource Management Act: A Review of Emerging Practice'. Summary of New Zealand Institute of Landscape Architects, Canterbury Branch Workshop *A Hard Act to Follow: Landscape and the Resource Management Act*, June.

and Principles'[94]. Underlying it is acknowledgment that, through their influence on the processes that flow through the landscape, people are inextricably part of ecosystems. It also acknowledges those ecosystems' *intrinsic* qualities, referred to by the RMA as 'those aspects of ecosystems… which have value in their own right'.

A reasonable outcome of the RMA then, in national, regional and local planning[95], and in the gathering of information and monitoring[96] to achieve its purpose, is the concept of the ecosystem as a dynamic unit of resource management. The concept's presence in the RMA springs from the Act's fundamental search for an on-the-ground, day-to-day, vernacular context for the somewhat elusive purpose of 'sustainable management'. Defined for practical application, as it has been, for example, by the United Nations Environment Programme for biodiversity assessment—*'all the individuals, species, and populations in a spatially defined area, the interactions among them, and those between the organisms and their abiotic environment'*[97].

While the RMA aspires in terms of resource productivity towards sustaining an essentially European social, economic

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[94] i.e. Purpose of the Resource Management Act 1991, (section 5b) '*safeguarding the life supporting capacity of… ecosystems*; (section 5c) *avoiding, remedying or* mitigating *any adverse effects of activities on the environment* ; Matters of national importance (section 6a) *the preservation of the natural character of the coastal environment…* ; Other matters (section 7d) *Intrinsic values of ecosystems,* i.e. *those aspects… which have value in their own right, including… the essential characteristics that determine an ecosystem's integrity, form, functioning, and resilience*; (section 7f): *Maintenance and enhancement of the quality of the environment.* **Note 1:** in the Resource Management Act's definition of 'environment', the primary sense is *'Ecosystems and their constituent parts, including people and communities…'* **Note 2:** although 'ecosystem' is not defined in the RMA, in the Environment Act 1986 an ecosystem is '*any system of interacting terrestrial or aquatic organisms within their natural and physical environment'.*

[95] i.e. sections 45–80 of the RMA.

[96] i.e. section 35 of the RMA.

[97] G.E. Likens (1995). *In:* 'Global Biodiversity Assessment', United Nations Environment Programme and Cambridge University Press.

and cultural landscape[98], it does so, in ecosystem terms, in the context of the state of health of an ancient Gondwana ecology[99]. It mediates between culture and nature to seek ways in which the ancient indigenous state of New Zealand can continue to sustain, inform and, in fact, be part of this unique landscape.

Recognition of the increasing severity of the range of environmental issues, and of their increasingly apparent interconnectedness, has meant the RMA's sustainability concept has evolved as an integrating one[100]. This systems-based, integrative approach to sustainability hinges on sustainability being:

'*the ability of a natural, human or mixed system to withstand or adapt to, over an indefinite time scale, endogenous or exogenous change that is perceived to be threatening'*[101].

A single primary principle underlies it: when an ecosystem component or process is pushed beyond its natural range of variability, that component or process, as well as others that depend on it, may not be sustained naturally. In other words, biological diversity and ecological function and integrity are at risk[102].

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98 i.e. '*managing the use, development... 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...* (Resource Management Act, Part II section 5(a): Purpose).

99 i.e. '*safeguarding the life-supporting capacity of... ecosystems; avoiding, remedying or mitigating any adverse effects of activities on the environment' ibid.*, section 5c: Purpose. Note that the Resource Management Act defines environment as primarily 'ecosystems and their constituent parts...'.

100 Stephen Dovers and Tony Norton (1994), Toward an Ecological Framework for Sustainability: Considerations for Ecosystem Management, *Pacific Conservation Biology 1*: 283–293.

101 Stephen Dovers and J. Handmer (1992), Uncertainty, Sustainability and Change. *Global Environmental Change 2*: 262–276.

102 Thomas Quigley and Stephen McDonald (1993), Ecosystem Management in the Forest Service: Linkage to Endangered Species Management. *Endangered Species Update* 10(3&4), Special Issue: 'Exploring an Ecosystem Approach to Endangered Species Conservation'.

Sustainability in this sense is different from 'sustainable development' in which concern with the health of the ecosystem serves as a mere modifier or constraint upon economic development rather than as an end in itself. As the UN commission that placed the notion firmly on the political agenda, defined it:

'*Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs'*[103].

In encompassing the innate, indigenous, pre-development state to the extent it does—in creating what is, in effect, a 'depletion model' of natural resource—it sets up the prospect of a future in which wild systems thrive in harmony with human society.

5.2.1 Ecosystems as a shared context

The management of biodiversity (as against its 'protection') requires an input of resources across all lands.... What the ecosystem approach has the potential to do is elevate the debate to a level of values and meaning. But to achieve this we must promote ecosystems as a shared context and not as some context outside of the 'production environment'. The ecosystem must be clearly seen as of equal importance to both conservation and production. The costs of ecosystem protection must fall largely in the immediate community of interest. [Clive Anstey] [104]

Any ecosystem must clearly be seen as encompassing both the conservation and production sectors, and be of relevance and importance to both[105]. To focus the public on its goal of sustainable environments, the Crown must

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[103] World Commission on Environment and Development—'The Bruntland Commission' (1987), 'Our Common Future', Oxford University Press, Oxford.

[104] Clive Anstey (unpublished) 'The Politics of Ecosystems', *pers. comm.* 1995 to author.

[105] Clive Anstey (unpublished), 'The Politics of Ecosystems', unpublished paper (PNAP Review 1994) to Department of Conservation, Wellington.

contribute resources, just as individual landowners and communities who inhabit the ecosystem, or are sustained by it, must make 'contributions in kind'. The most fragmented, 'at-risk' ecosystems involve multiple ownership. Restoration needs to become sustainable again.

With its concern for integrated management, the RMA says regional planning must move to address the environment not just as soil, or water, depending on the issue of the moment, but 'as a complete system, rather than a number of separate parts, each with its own set of professionals'[106]. It was this sense of life and land as systems that a judge[107] had in mind when he commented soon after the gazettal of the RMA: 'we are moving toward recognition of the importance of preserving ecosystems'[108].

While the RMA defines ecosystems and the natural state in ways that tend to be vague and difficult to translate into resource management practice, its systems approach makes the inter-relatedness and inter-connectedness of living things visible and operational. It recognises that human culture is part of this; that people shape nature simply by the interaction implicit in the act of inhabiting it. But the RMA needs to be interpreted with an understanding of New Zealand's particular ecological circumstances. The RMA's respect for the life-supporting capacity of the natural state, and the intrinsic values of ecosystems, allows nature some safeguarding and to retain some real independence from humanity.

5.2.2 Statutory ecosystems—their basis in law

The RMA has been acknowledged as 'marking, and in part directing, a change in the way in which people regard the

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[106] Rt Hon. Geoffrey Palmer (unpublished), 'Resource Management Law Reform', Speech to the last New Zealand Catchment Authorities Association Conference, Hamilton, 19 April, 1989.

[107] i.e. now Environmental Court.

[108] Arnold R. Turner (1993), Why Protect Endangered Species?' *New Zealand Journal of Forestry*, August.

world'. References in the Act to intrinsic values, the environment and landscape are important, one lawyer said, 'more because they mark a shift in the way people think than because of what the Act actually does'[109]. Central to this shift is the primary position of 'safeguarding the life-supporting capacity of… ecosystems' as a fundamental element of the RMA's purpose and principles.

New Zealand's environmental legislation first used the term 'ecosystem' in the general purposes of the Reserves Act 1977, 'ensuring, as far as possible, the preservation of representative samples of all classes of natural ecosystems….'[s3(b)]. Neither 'natural' nor 'ecosystem' is defined. Ecosystems, the Reserve Act infers, can be classified and represented, even *preserved,* in discrete protected areas. Natural ecosystems can be distinguished from non-natural ones. As a result, the surveying and evaluative activity of the PNAP that flowed from it, became preoccupied with the indigenous and separating it from the rest of the landscape—as if it were islands of wild indigenousness in a sea of domestication.

The position of ecosystem-based principles in Part II of the RMA is important. Included as an 'Other Matter' to which to 'have particular regard', 'the intrinsic values of ecosystems' (section 7d) is a minor rather than major principle. Nonetheless, it triggered much debate as it proceeded to become law. Integral to it, right through to the select committee stages, was the ancient Polynesian life principle *mauri*, the quintessential evocation in tikanga Maori of the ecosystem concept: '*the elemental force that binds all things together and gives them their meaning'*[110].

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[109] John Milligan (unpublished), 'A Lawyer's View'. Summary of NZILA, Canterbury Branch workshop, *A Hard Act to Follow: Landscape and the Resource Management Act.* June 1994.

[110] Rev. Maori Marsden (1975), 'God, Man and Universe: A Maori View'. *In:* Michael King, *ed.*, 'Te Ao Hurihuri: The World Moves On'. Hicks Smith & Sons, Wellington. Quoted in Taiaraka Black, submission to the Planning & Development Select Committee on the Supplementary Order Paper, Resource Management Bill, NZ Parliament, 31 May 1991.

Mauri is about sustainability, but in more than the physical sense. It has metaphysical connotations; the *tapu* nature, no less, of human coherence with resources that if 'interfered with or desecrated… would be in a perilous condition and open to assault by all things'[111]. 'The inclusion of intrinsic values of ecosystems' as a principle of the RMA is consonant with such terms in the Act as the 'biological and genetic diversity' of ecosystems and 'the essential characteristics that determine an ecosystem's integrity, form, functioning, and resilience… have values in their own right'[112]. It is said as though the Act's authors have not only broken free of resource management's traditional assumption of the exclusive supremacy of one species alone, our species' valuing of the rest of the world's life in our own image[113].

Mauri's vital meaning, in ecosystem terms—the self-inseparable from its environmental context—is still implicit, nonetheless, within its purpose and principles. Section 7(a) of the RMA requires that all people exercising functions and powers under it have particular regard to *kaitiakitanga*, a facet of Maori resource management that has persisted through European colonisation. Legal interpretation refers to kaitiakitanga including the actions that tangata whenua take in 'protecting and enhancing the mauri of their taonga'[114].

Just as the ecosystem concept is holistic in its inclusiveness[115], kaitiakitanga, with its interconnecting of the land and its life, the sea and the sky, is in direct conflict

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111 Marsden, *op. cit.*

112 B.V. Harris (1993), Sustainable Management as an Express Purpose of Environmental Legislation, *Otago Law Review 8(1)*: 51-76.

113 *ibid.*

114 An important principle recognised by The Board of Inquiry into The New Zealand Coastal Policy Statement, in its Report and Recommendations. Department of Conservation, Wellington, 1994, p. 103.

115 *ibid*. Both contain the notion of life force, and both assume all natural and physical elements of the world—the seas, sky, forests and birds, food crops, winds, rain and storms, volcanic activity, as well as people—to be related to each other.

with the reductionist perspective of the legal system[116]. Nor do the spiritual and esoteric meanings it embodies sit easily in the domain of the RMA planning process and the legality of land and property underlying it. The challenge is to define and understand what New Zealand's different ecosystems might be in terms meaningful to both Maori and Pakeha, and how to inhabit them in ways that respect that.

How then do we sustain what the RMA calls the life-supporting capacity of such an ecosystem, its intrinsic values, its natural character? The modern concentration of human settlement on floodplains, for example, is a long-standing problem for human health and biotic integrity[117]. Flood plains, in other words, are for *floods*.

The RMA accords the ecosystem concept such importance because its own proactive stance, its embracing of ecosystems 'in their own right', their 'integrity, form, functioning, and resilience'[118] distinguishes it from resource planning's historical human-centredness and its concern with issues. But allowing that culture is dependent upon at least some modification of nature, it does so recognising that[119]:

- The health of ecosystems is basic to having a healthy economy and social system.
- Ecology is about connections which may cross ownership and political boundaries.

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[116] P. Nuttall and J. Ritchie (1995), Maori Participation in the Resource Management Act, An Analysis of Provision made for Maori in Regional Policy Statements and District Plans produced under the RMA 1991, jointly published by the Tainui Maori Trust Board and the Centre for Maori Studies, University of Waikato.

[117] Alan Cooperrider and Reed Noss (1994), Saving Aquatic Biodiversity, *Wild Earth*, Spring.

[118] Resource Management Act 1991, Pt.I,2: interpretation of 'intrinsic vales, in relation to ecosystems'.

[119] Judith Roper-Lindsay (n.d.), A Discussion of Ideas, Problems and Opportunities Presented by the Act to Local Authorities. *Resource Management Ideas, No 1 Ecology and the Resource Management Act*. Ministry for the Environment, Wellington.

- Ecological time scales vary, and many effects will take place outside the political or development time frame.
- Change is a natural part of ecosystems; plans must be flexible enough to respect natural processes while preventing unwanted change.

However, nowhere in the Resource Management Act is 'ecosystem' defined; and when it is, in the parallel legislation of the Environment Act, it is with a total absence of specificity. 'Parliament has deliberately left the wording indeterminate'.

The Resource Management Act's 'express recognition of the importance of ecosystems to the maintenance of life is an acknowledgment of the need for humans to avoid interfering with nature's order and balance'[120].

By their very existence as statutory requirements to consider ecosystems, the Reserves Act 1977 and the Resource Management Act 1991 spawn satellite programmes that define ecosystems for their particular purposes[121]. However neither the Reserves Act, its various Amendment Acts 1979–96, nor the Conservation Act 1987, the Conservation Law Reform Act 1990, or the RMA define ecosystems. One legal interpretation of why the RMA's loosely guided discretion with regard to section 5(2) has been 'left with rule-makers and decision-makers'—why key concepts like ecosystem and life-supporting capacity (section 52) have been left 'so vague' and flexible—lies in the 'inevitable balancing' which the Act requires between current development interests and long-term environmental ones. Parliament can be criticised for leaving it so indeterminate, thereby abdicating its law-making responsibilities to the courts[122].

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[120] Harris (1993), *op. cit.*

[121] e.g. the Protected Natural Areas Programme under the Reserves Act 1977, and Regional Policy Statements, Regional Landscape Plans. Freshwater Plans, etc. under the Resource Management Act 1991.

[122] Harris (1993), *op. cit.*

Section 5 has not yet been subject to any significant judicial analysis[123]. Construed strictly, the requirements of its second clause to 'safeguard the life-supporting capacity of air, water, soil and ecosystems', could allow little at all in the way of human activity or development to take place in any essentially indigenous ecosystem. That is neither what those who brought the RMA into law intended, nor what most local or regional decision-makers will allow. But by deliberately leaving section 5's wording confused and indeterminate[124], Parliament has effectively transferred to local and regional communities and their resource planners and managers, the responsibility of mediation, and the setting of objectives for sustainability. In doing so they have transferred the risk of further environmental attrition that the RMA was designed to eliminate.

The question therefore arises as to how best to introduce the RMA's sense of New Zealand as ecosystems to wider New Zealand society? Recognising the privatised nature of our landscapes and that their biodiversity had been comprehensively simplified from their natural state, some regional councils immediately saw the need to use '*statutory public participation processes as an opportunity to increase public awareness of ecosystem considerations*'. They include '*setting a good example of ecosystem awareness when carrying out operational responsibilities*'[125]. But few can set out what a region's ecosystems are, how they function and how sensitive or resilient they are, let alone predict for any particular ecosystem what the RMA calls the 'adverse environmental effects' are of any activity.

Given most ecosystems' real extent, it is rare that an individual agency or landowner has responsibilities to manage an entire ecosystem. Nonetheless New Zealand's regional councils were soon responding to the challenge:

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[123] *ibid.*

[124] *ibid.*

[125] *ibid.*

'taking these relatively abstract and uncertain definitions of ecosystems, and applying them in a meaningful way to the development of policy'[126]. The key to this, of course, is the way in which a region's ecosystems are defined and evaluated in the resource management process. How might this be done?

5.2.3 Regional ecosystems—the ecosystem as a criterion for land policy

The Policy Statement provides no indication as to what ecosystems occur within the.... Region and no guidance as to the basis of identification and depiction. I suggest that the boundaries of the Region's ecosystems could usefully be defined on the basis of common, unifying processes in the landscape which determine the natural character of their contents. In my opinion, the Council is likely to be more effective in maintaining the life supporting capacity of ecosystems within its area of responsibility if it knows what they are and where they occur. [Theo Stephens][127]

By employing the ecosystem concept in the way it does, the RMA evokes ecology as a guide to an integrative systems-based approach to sustainability. The Act requires each regional and local authority to monitor its environment 'to the extent that is appropriate to enable [it] to effectively carry out its functions'[128]. The understanding in so doing is that ecosystem-based resource management goes beyond bringing the myriad sites with indigenous values into the purview of the planning process. It is as much about the country in between those sites, the processes linking them that are vital to the coherence of natural systems in time and space, about evolving ways to live within the limits of these systems, and using the resource planning process to communicate those understandings.

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[126] *ibid*.

[127] Theo Stephens (unpublished), 'Submission on Waikato Regional Policy Statement' Waikato Conservancy, Department of Conservation, March 1995.

[128] Resource Management Act 1991, section 35(a).

As a result, once the Act became law, Regional Policy Statements began to emerge with substantial focus on ecosystems as targets for environmental management.

The Regional Policy Statement's concern with ecosystems distinguishes ecosystem-based resource management from the approaches that prevailed prior to the Resource Management Act. It sets down the facts of historic decline in the number and area of certain indigenous ecosystems and in their species diversity, and the continuing deterioration of the region's ecosystems in general and the poor conservation status of many. The Resource Management Act's key purpose of sustainability underlies the propositioning question *'what condition do we want our Region's ecosystems to be in for future generations?'*

From that, a policy objective is established to increase the overall quality of the region's ecosystems, indigenous and modified, to increase their area, and to ensure that healthy functioning ecosystems are distributed throughout the region. We understand that ecosystem quality is in terms of the links between various ecosystem components; ecosystem processes, such as regeneration or succession; the non-living elements maintaining their natural characteristics and processes; the ecosystem having high species diversity appropriate to its type; and the ecosystem being resilient or adaptable.

Without a sound ecosystem approach to information bases included formally in the resource management process, the RMA's goal of sustainable ecosystems will be subject to compromise. As Aldo Leopold said in 1933, *'The hope of the future lies not in curbing the influence of human occupancy—it is already too late for that—but in creating a better understanding of the extent of that influence and a new ethic for its governance'*[129].

[129] Aldo Leopold (1933), 'Game Management'. Charles Scribner's Sons, New York.

5.2.4 Ecosystems and state-of-the-environment reporting

Given the facts that current land use of perhaps half of the New Zealand land bank is unsustainable, and that the nutrient capital of its soils are in general decline, the remnants have a value for base-line monitoring. The remnants themselves however, are rarely in a healthy ecological state, or in equilibrium with the land uses with which they co-exist. They themselves need greater care if they are to become sustainable. [Geoff Park][130]

A major challenge for the concept of sustainable environmental management emerging as a legal[131], political[132] and research[133] objective, has been the development of indicators that, environment by environment, can accurately reflect ongoing trends.

State-of-the-environment reporting encompasses systematic monitoring, gathering, and analysis of environmental data. It also involves the dissemination of reliable, scientifically based, easily understood information about the condition (state) of the environment, the pressures on it, and the effectiveness of the measures taken to correct any problems[134]. It is provided for and required by New Zealand's Resource Management Act (section 35) as a function of local authorities.

State-of-the-environment reporting is seen as a 'very effective way of giving people a greater understanding of how their daily activities affect the environment'[135].

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130 N.Z. Ministry of Research, Science and Technology (1995) Science for Sustainable Land Management: Towards a New Agenda and Partnership. November, p. 53.

131 i.e. the purpose of the Resource Management Act 1991.

132 Environment 2010 (1994), Statement on the New Zealand's Government's Strategy on the Environment.

133 Strategic Consultative Group on Sustainable Land Management Research (1995), 'Science for Sustainable Land Management'. Ministry for Research, Science and Technology, Wellington.

134 Ministry for the Environment (1996) 'National Environmental Indicators: Building a Framework for a Core Set', Wellington.

135 *ibid.*

They do this not only by influencing the way its ecological layout is depicted, but by pinpointing crucial natural *dynamics* that should be monitored and maintained.

6. Evaluating ecosystems

...whether or not an ecosystem is stable and integrated is, first, a matter of descriptive fact, ... secondly, a matter of evaluation and prescription. [Holmes Rolston] [136]

Part of the difficulty of interpreting and using the term 'ecosystem' is that it comes at us in a range of ways.

Many commonly use the ecosystem concept to define and differentiate types of environment—high country ecosystems; forest ecosystems; alpine ecosystems; gorge ecosystems; coastal ecosystems; geothermal ecosystems; dune ecosystems; wetland ecosystems; estuarine ecosystems; island ecosystems; pasture ecosystems; urban ecosystems, etc.

However, one is also likely to hear the same term being used in the sense of:

- Proactive conservation management: '*since the landscape is fragmented and much wildland has been converted to other uses, the boundaries and coverage of some protected areas may not conform to the size and shape of the ecosystems that are to be maintained and managed'*.
- Challenges of managing at '*the whole ecosystem scale*'.
- Strategies for promoting sustainable management of '*the entire ecosystem complex*' [137].
- A nation-wide assessment of the representativeness of ecosystem types needing to be supplemented by more specific studies of '*the extent of ecosystem decline*' and conservation and restoration plans for each region's '*component ecosystems*'.

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[136] Holmes Rolston (1994), in Foreword to Laura Westra 'An Environmental Proposal for Ethics: The Principle of Integrity.' Rowman and Littlefield, London.

[137] Kenton R Miller (1995), 'Balancing the Scales: Guidelines for Increasing Biodiversity's Chances through Bioregional Management.' World Resources Institute.

Many ecologists, conservation and resource managers have traditionally ignored the concepts of coherence and connectedness across a landscape or stretch of country. Treating these often isolated examples as discrete ecosystems, distinguishing them by habitat or community homogeneity[138], they have been led by the ideal-state notions of 'the balance of nature' rather than the more appropriate, dynamic 'flux of nature'. Ecosystem conservation needs to attend to the:

- Processes governing the system.
- Context in which it is embedded.
- Historical range of flux in the system.
- Evolutionary and physiological limits of the system's species.
- Nature and impact of episodic and long-term phenomena, including people past and present.[139]

Ecologists skilled to discern, analyse and interpret the moving mosaic of life in a landscape are inevitably aware of what are called *whole ecosystems*[140]: a bigger picture above and beyond its species and their habitats and communities; a systemic network of spatial and temporal life patterns and processes about which those lower levels of organisation tell little.

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[138] Reed F. Noss (1983), 'A Regional Landscape Approach to Maintain Diversity', *BioScience 33(11)*; Forman, R.T.T. (1981), Interactions Among Landscape Elements: a Core of Landscape Ecology. *Perspectives in Landscape Ecology*, Proceedings of the International Congress of Landscape Ecologists, Veldhoven, Pudoc Publishing, Wageningen, The Netherlands, pp.35–48.

[139] Steward T.A. Pickett, V. Thomas Parker and Peggy L. Fielder (1993) 'The New Paradigm in Ecology: Implications for Conservation Biology Above the Species Level'. *In:* Peggy L. Fielder and Subodh K. Jain, *ed*. 'Conservation Biology: The Theory and Practice of Nature Conservation Preservation and Management', Chapman and Hall, New York and London.

[140] Kenton R. Miller, *op. cit.*; Dave Foreman and Reed Noss (1992), The Wildlands Project Mission Statement, *Wild Earth* Special Issue; G.H. Campbell (unpublished draft), *Towards a Biodiversity Action Plan for the Department of Conservation,* Department of Conservation, Wellington, June 1996 (draft).

In any large stretch of country, whether wild, natural forest or a mosaic of modification, the natural pattern of disturbance and recovery creates a dynamic but regionally distinctive and persistent ecosystem complex. Science's recognition of the inherently chaotic properties of biological systems, compounded by an ever-changing environment, has dashed hopes that the imperative of nature's ecosystems is toward a predictable and self-sustaining equilibrium[141].

Nonetheless nature does have systemic organisation at the landscape scale—in fluxes of nutrients and energy, the movement of pollen, seed and species themselves, etc. There is connectivity and coherence, more difficult to measure and delineate by a tractable set of variables than is community homogeneity, but qualitatively comparable—if only by approximation. We can compare:

- A coherent natural ecosystem, a shifting mosaic of all community types unmodified by human use, in equilibrium with its environment, and
- A fragmented ecosystem with a pattern of disturbance and recovery so disrupted that the shifting mosaic has virtually nowhere to shift.

In the comparison, almost beyond our grasp it seems at times, are the value concepts of ecosystem integrity, health and sustainability within which fits the range of parameters explored in earlier sections.

141 Stephen Budiansky (1995), 'Nature's Keepers: The New Science of Nature Management'. Weidenfeld & Nicholson, London, pp. 82–99.

7. Keystones: ecosystem integrity, health and sustainability

If the value of ecosystem integrity is understood, and the appreciation of its complex functioning is enhanced, then we will be in a better position to understand the limits …of using science better to understand ways of benefiting from nature without harming the source of such benefits. We will then be able to ensure sustainability and maintain maximum ecosystem health to support defensible human uses of such ecosystems. [Laura Westra][142]

7.1 ECOSYSTEM INTEGRITY

Integrity in ecosystems includes the capacity to evolve. Stability and nothing more would squelch this creativity… life perpetually sustained and renewed. There is cycling and re-cycling of energy and materials. The member organisms flourish in their interrelated niches. The system is spontaneously self-organising in the fundamental processes of climate, hydrology, speciation, photosynthesis and trophic pyramids. There is resistance to, and resilience after perturbation… [Holmes Rolston][143]

Central to the appraising and care of ecosystems is the valuing of wholeness and unbroken functioning. Imagine on one hand, a contiguous, native forest ecosystem with its vital processes intact, no roads, artificial clearings or altered or contaminated watercourses, no exotic weed species, that is regenerating itself, is buffered from the cultural landscape and is resilient to current environmental stresses. On the other hand, imagine a geomorphically and climatically

[142] Laura Westra (1994), 'An Environmental Proposal for Ethics: The Principle of Integrity.' Rowman and Littlefield, London.

[143] Holmes Rolston III (1994), in Foreword to 'An Environmental Proposal for Ethics: The Principle of Integrity', Rowman and Littlefield, London.

similar stretch of country, roaded, drained, with human dwellings and gardens and abounding with exotic weeds, with its former native forest broken into isolated patches, fenced off but unbuffered from the surrounding farms, with few of its natural seed dispersers and barely regenerating.

Pressed to compare the two ecosystems, a conservation ecologist would inevitably say the former has far greater integrity. It is constituted of the species native to that stretch of country. It is allowing their evolution to continue in the natural state, it is whole, healthy and relatively stable, and it is replacing itself. The importance of ecosystem integrity as a key concept of biodiversity conservation is that protecting just a representative example of that forest ecosystem is, in *ecosystem* terms, clearly not enough. Some of the values vital for its long-term future reside, still unprotected, in the wider landscape. Where ecosystem integrity has been most subjected to critical analysis as a philosophical, legal, biological, cultural and ethical principle, its absolute value is as a benchmark of the *pristine, wilderness state*[144]. This understanding makes explicit its use of ecology, systems theory and the laws of thermodynamics.

Implicit in most definitions of ecosystem integrity, and a major source of specific biological measures of it, are an ecosystem's constituent *native* species—the full range of biota evolutionarily adapted for a stretch of country. To this perspective, the most important elements of conserving ecosystem integrity are:

- Maintaining both natural variability and inter-connectedness of physical habitat within large continuous species and along those corridors that are essential for the migration and dispersal of native biota.
- Maintaining native species wherever and whenever these plants and animals still remain in their natural habitats.

[144] Westra (1994), *op. cit.* p.27.

- Providing for restrictions on those 'naturalised' non-native species so as to limit their dispersal and spread into areas where they may disrupt naturally sustainable ecosystems.

The idea that ecosystems have integrity—and that this can be conserved (or lost) as well as compared—is in legislation[145], but you will not find it in basic ecology texts. Strict measurement of it is similarly elusive; as Holmes Rolston says, it has begun to slip around as soon as we start to think about it[146]. Even in its ecological sense of wholeness it is synthetic, embracing simpler concepts like connectivity, intactness, diversity and resilience and is more difficult than these to quantify. But this does not mean it should be denigrated as loose, soft or rhetorical.

The utility of integrity for ecosystem conservation has been subsequently sharpened by definitions of it as '*the maintenance of the community structure and function characteristic of a particular locale or deemed satisfactory for society*'[147]. Under the influence of modern ecology and systems theory, it has moved beyond the connotations of a fixed state. Thus terms like 'preservation' still in legislation[148] give way to a sense of ecological process and life forces and the imperative of keeping natural systems as close as possible to their native, dynamic steady-state.

The value of ecosystem integrity is its capture of this dynamic. We need to know what it has been historically and where it is trending. Our focus must extend above and beyond the species level and the site. Two hypothetical goal statements show the difference:

The species-community-place paradigm: we want to preserve the kereru population and rare forest types in the

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145 New Zealand's Resource Management Act 1991 for example: Part I, section 2 as a primary component of an ecosystem's intrinsic values : Part II section 7(d)

146 Holmes Rolston III (1994), *op. cit.*

147 J. Cairns 1977, quoted in Noss (1983), *op. cit.*

148 New Zealand's Reserves Act 1977, for example.

Horowhenua plain lowland forest remnant at Lake Papaitonga Scenic Reserve and will do so by managing the reserve.

The ecosystem paradigm: we want to maintain the integrity of the lowland forest ecosystem that nature generated on the Horowhenua plain and will do so by understanding and maintaining the processes that created it, particularly those of seed dispersal, etc. of its keystone species such as kereru. We will do so by better understanding the ecosystem and its history, by taking opportunities to eliminate, avoid and reduce impacts on what remains of the indigenous qualities of the ecosystem, as well restoring it, alongside maintenance of the conservation endeavour at Lake Papaitonga Scenic Reserve.

It should be noted that many ecosystems, threatened and precious in indigenous terms, commonly include non-indigenous species. The question needs to be asked whether legal interpretation will distinguish, in this regard, between ecosystems prevailed upon by native species and those by non-native species. Or whether the integrity of a New Zealand natural ecosystem is reduced by the mere presence of *any* non-native species that can enter, spread and do well in it?

The essence of ecosystem integrity lies in an ecosystem's capacity to regenerate itself, to be resilient in the face of natural surprises and perturbations, and to be able to initiate, again and again, the processes leading to the path of self-organisation.

With the two ‘desired states’ of nature and culture alongside one another in the landscape, to be useful in practice ecosystem integrity needs to allow for two senses of its meaning. This is: the wellbeing of the state which has been brought into being by nature, and the wellbeing of the state brought into being by culture.

In the literature, integrity ranges from something measurable in terms of species loss and the replacement of native species by exotic, or non-native, species to thermodynamic properties of ecosystems. The key to evaluating it, though, as we have seen throughout this review of the ecosystem concept, is to define the scale, the perspective and the ecosystem components in their various states[149]. And just as the landscape—certainly the landscape of New Zealand's more threatened ecosystems—contains multiple steady states, it has no *one* preferred observer.

It must be resilient and viable, long-term—to continue evolving and developing. It is these two aspects of ecosystem integrity that distinguish it from the narrower notion of ecosystem health.

7.2 ECOSYSTEM HEALTH

While species are of course important because species are essential participants in natural dynamics, we intend to shift the focus of biodiversity policy to protecting the health of socially important natural processes. [Norton and Ulanowicz][150]

Ecosystem health is obviously related to ecosystem integrity, and embraced by it, but many authors give it separate status[151]. Ecosystem health is difficult to define and measure but it is a useful concept. Certainly many will find more meaningful the assertion that New Zealand has many unhealthy ecosystems than that it has many ecosystems with low integrity.

It is in the analogy between the health of an ecosystem and a human body that conservation ecology is sometimes compared with cancer biology. Someone who has lost a finger or even had cancerous tissue removed, may be healthy in the sense of being as capable of disease resistance as before the event. Yet in both cases, the individual's integrity has been diminished. An ecosystem

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[149] Stephen Budiansky (1995), 'Nature's Keepers: The New Science of Nature Management', p. 135. Weidenfeld and Nicholson, London.

[150] B.G. Norton and A. Ulanowicz (1992), Scale and Biodiversity Policy: A Hierarchical Approach. *AMBIO 21(3)*.

[151] R. Costanza, B.G. Norton and B. Haskell (1992), 'Ecosystem Health: New Goals for Environmental Management'. Island Press, Washington D.C.

may be in an altered state, with a few vanished minor species, or a few additional, non-aggressive, adventive ones and thus of reduced integrity from its full complement of native species and without adventives. But it can still be quite healthy.

Ecosystem health has been defined as including (1) homeostasis; (2) the absence of disease; (3) diversity or complexity; (4) stability or resilience; (5) vigour or scope for growth; (6) balance between system components[152]. It also strongly emphasises functional over structural features. It is also understood more in relation to specific locations and time frames. Where ecosystem integrity has a long-term inter-generational thrust, health is limited to actual manifestations in existing populations or species.

It has been argued that all aspects of human activity within ecosystems gain their life support ultimately from ecosystems in their primary, wild state; that we depend on their resilience in the long term. The emphasis that environmental policy makers and scientists place on ecosystem health, and its concerns with the present and the immediate future, is considered dangerous from this perspective because it diminishes the importance of the wild state as foundational to sustainability[153].

7.3 ECOSYSTEM SUSTAINABILITY

Sustainability is rapidly emerging as a key concept in biodiversity conservation and resource management in response to the general impression, world-wide, that within the past half century there has been a decline in the 'health' of many of the earth's ecosystems. Influencing what is widely acknowledged as a major challenge of the age is the creation of a living and working environment in sympathy with natural ecological systems with their own intrinsic

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[152] *Ibid.*

[153] Westra (1994), *op. cit.*; Laura Westra and John Lemons, *eds* (1995), 'Perspectives in Ecological Integrity'. Kluwer Academic Publishers, Dordrecht, The Netherlands.

values. That is why New Zealand's Resource Management Act, with sustainability its primary purpose, incorporates so-called 'deep ecology' concepts like intrinsic values and the attaching of ecosystem integrity to a ecosystem's primary, natural state.

Given the environmental origins of the concept of sustainability, ecological science has become the primary focus of attempts for it to replace the ideas of progress and growth as the organising concepts in Western understandings of the future. Shorn of the connotations and nuances that come with its plurality of uses, ecosystem sustainability is simply the ability of an ecosystem to maintain itself undiminished over some time period. It is inevitably set against anticipated trends of human demand and use through that same period. It therefore requires explicit or implicit answers to three kinds of questions:

What is to be sustained, and at what scale, and in what form?

Over what period of time and with what level of certainty?

Through what social process and with what trade-offs against other social goals?[154]

Ecosystem integrity, and to a lesser degree ecosystem health, carry strong connotations of the natural, primary state of an ecosystem as the benchmark of valuing. However, criteria-setting frameworks for ecosystem sustainability are invariably far less constrained. Preservationism and the exclusion of humans from ecosystems with which they have not co-evolved, have lost out world-wide to the idea that pristineness, while valuable, is commonly neither possible nor necessary.

This recognition had led to scientific efforts towards identifying fundamental, essential variables and biophysical limits that cannot be violated without causing long-term human harm. The questions below, for example, are from

[154] Sharachchandra Lélé and Raichard B. Norgaard (1996), Sustainabilty and the Scientist's Burden, *Conservation Biology 10(2)*: 354-365.

an Australian study of ways to assess the sustainability of ecosystems:

1. Ecosystem status and threats:

- What is the current status of and long-term prognosis for the ecosystem with respect to human use: i.e. is it being used sustainably, as defined?
- What are the significant threats to ecosystem sustainability at present, and likely in the future?
- If any, what are the accepted, testable societal goals for the status of the ecosystem in the long term? (i.e. goals whose achievement can be monitored)?
- If the ecosystem is being exploited unsustainably, what changes in the use and management are evident that may help achieve these goals?

2. Factors in current policy and management:

- What are the operative time scales for (a) the ecosystem itself or key components thereof, and (b) the interacting human systems of policy, exploitation, management and monitoring? Do these markedly differ and what problems arise?
- What are the key interdependencies between the ecosystem in question and other natural and human systems, and what are the policy and management implications of these linkages?
- What is the nature of the market (formal) and non-market (informal) good and experiences consumed from the ecosystem, and what are the social and cultural aspects of patterns of management? Are the two sets balanced appropriately in management?

3. With respect to knowledge:

- Does adequate information exist for ecosystem management for sustainability of both the human and natural systems in question?
- What are the key indicators that can be used for monitoring progress towards sustainability?

- What are the major areas of ignorance and uncertainty in both the human and natural systems, and how do policy formulation and decision making processes take account of these?

4. Future priorities:

- How far from the long-term goal of sustainability is the present situation?
- Are the current policy and management arrangements adequate; i.e. is the pattern of *sustainable development* likely to lead to *sustainability* at some future time?
- If not, what are the changes to research, policy and management and use required to achieve ecosystem sustainability?[155]

[155] S.R. Dovers and T.W Norton (1994), Towards an Ecological Framework for Sustainability, *Pacific Conservation Biology 1(4)*.

8. Translating the ecosystem concept into delineated geographic units

One major problem is classification; ecologists can argue for years about the best way of classifying all the habitats or communities in a region and about which level of splitting or lumping is optimal for conservation purposes. [Reed Noss][156]

8.1 PURPOSE, THE KEY QUESTION

The great diversity of New Zealand's ecosystems, and the fact that many of them are suffering declining integrity and health, suggest that they are a necessary subject for national assessment in a similar way to threatened species. Using the parameters by which ecologists commonly depict ecosystems and assess their condition and the extent of threat to them, a recent preliminary assessment of the ecosystems of the United States has identified those considered to be critically endangered, endangered and threatened.[157]

Such a framework is only possible if the continuity of ecosystems in time and space can be partitioned in some way. When it comes to time, it is common enough in conservation circles to hear someone refer to 'the lowland pastoral ecosystems and the forested upland ecosystems of the Bay of Plenty'; or how South Westland has 'the most intact suite of lowland ecosystems'; or how 'the health of Horowhenua dune lake ecosystems is in decline'.

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[156] Reed F. Noss (1995), What Should Endangered Ecosystems Mean to the Wildland Projects? *Wild Earth*, Winter (21).

[157] Reed F. Noss, Edward T. LaRoe and J. Michael Scott (1995), Endangered Ecosystems of the United States: A Preliminary Assessment of Loss and Degradation, *Biological Report 28*, National Biological Service, Washington D.C.

But these same situations could be expressed quite differently: ‘the modified lowland and intact upland components of the Bay of Plenty’s ecosystems’; how South Westland has ‘the only lowland plain ecosystem with its suite of communities intact’; how ‘the last surviving components of the Horowhenua lowland plain ecosystem, its dune lakes, are in decline’.

Only the latter group conveys that there is something *systemic*—a life-support system—functioning at the landscape scale, straddling the Bay of Plenty, South Westland or Horowhenua Plain from mountains to sea; that each was once intact in the indigenous ecosystem sense, and functioning differently.

Another, altogether different purpose could partition the Horowhenua plain into sand dune, sand plain, alluvial plain, river, peatland, dune lake and estuarine and lagoon ecosystems. Or, regardless of its landform or vegetation cover, it could make it part of a warm temperate, humid coastal ecosystem and the South Westland plain part of a cool temperate, coastal one. The ecosystem concept’s utility is this flexibility; key to the choice of ecosystem is purpose.

8.2 SCALE

In bioregional management, there is no one single right scale at which to work. A bioregion of several tens of thousands of hectares is appropriate for some ecosystems that comprise mountain slopes and whole watersheds.... To be practical, communities, residents, resource managers, and government agencies will want to define the bioregion in terms that most residents and resource-dependent people think of as home.... Thus the right scale is determined by dialogue and informed by science, *technology, information, and social considerations.* [Kenton Miller][158]

For any ecosystem, what scale best enables insight into the state it is in; the dynamic interaction between core reserves, buffers and the matrix of lands used more intensively by humans?

Ecosystem-based conservation brings with it the principle that there is no one, single, right scale at which to work. Conservation biology, in New Zealand and elsewhere, has traditionally focused on the individual site and the fine scale and species level of organisation. It has generally identified these values in standardised ways and at specific map scales: e.g. the 1:50,000 scale at which the NZ PNAP surveys map 'ecological units'.

Holistic concepts like integrity and health or more specific ones like intactness, connectivity and diversity are all measures that present enormous problems related to scale and sample size[159]. If anything is scale-dependent, it necessarily displays quantitative changes with a shift in the scale used to observe. This is exactly what happens with ecosystems. A given ecosystem's real extent in the landscape—a lowland plain forest, say—is a function of the scale at which the vital processes shaping it operate and the human scales of perception at which we recognise these processes and criteria. The criteria that are used to delineate it, distinguishing it from another ecosystem and evaluating it, must recognise this. If there is any one prevailing use of the term 'ecosystem' it is in the sense that ecosystems *contain* communities, and are larger-scale than them. Furthermore, many who have looked at the global problems of biodiversity, consider that 'larger-scale

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[158] Kenton R. Miller (1996), 'Balancing the Scales: Guidelines for Increasing Biodiversity's Chances through Bioregional Management', World Resources Institute, Washington, D.C.

[159] Reed Noss (1990), 'Can We Maintain Biological and Ecological Integrity', *Conservation Biology* 4(3): 241–243.

approaches [are] the only way to conserve the overwhelming mass of species' [160].

The fundamental importance of scale in the issue of ecosystem depiction and delineation is by way of the ecosystem concept's emphasis on connectivity:

If a management prescription is to benefit from this value, then the scale of subdivision should bring together differing habitats and communities that have linkages, not separate them. [161]

Not least of the scale problems that arise in depicting and delineating ecosystems is that a single ecosystem is itself a hierarchy of differently scaled processes. Many mobile keystone species like kereru, for example, cannot be readily defined by spatial criteria. A series of encouraging, or at least guiding principles might be:

1. All ecological processes and types of ecological structure are multi-scaled. Each particular structure relates to a particular scale used to observe it such that, at that scale of perception, the entity appears most cohesive, explicable and predictable. Scaling is done by the observer; it is not a matter of nature-independent observation.

2. Structures that match human scales of perception are the most well known and are the most frequently discussed. Ecological processes are usually couched in terms of familiar structures. The scale of these processes is prescribed by (a) tangible structures, and (b) a context that is also scaled so as to be readily observable. A common error is to leave the context undefined and so unscaled, at which point discussion become ambiguous.

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[160] Anthony W. King (1993), 'Considerations of Scale and Hierarchy', *in*: S. Woodley, J. Kay and G. Francis, 'Ecological Integrity and the Management of Ecosystems'. St Lucie Presss, Ottawa, Canada, pp. 19–46.

[161] I.A.E. Atkinson (unpublished), 'The Nature of Ecosystems, New Zealand Ecosystems in Particular', paper presented at Department of Conservation forum on ecosystem depiction, April 1995.

3. It is sensible to determine the appropriate scale of perception separately from choosing the type of system.[162]

8.3 OBSERVATIONAL SETS

By observational set we mean a particular way of viewing the natural world. It includes the phenomena of interest, the specific measurements taken, and the techniques used to analyse the data. The time-space scale is an important property ... determining the number of measurements taken and the intervals between them. [O'Neill et al.][163]

If ecosystems can only be depicted and delineated for a particular purpose, how do we select components or parameters that capture the essence of their dynamics? Or that lead people to understand what they are, and that can represent them? These have been called 'observation sets': for example, by focusing exclusively on either the population-community or process functional view of ecosystems[164].

The choice of observational set must be tied to the purpose of the operation: the problem being addressed. The operational set for profiling New Zealand as ecosystems, in other words, will need to comprise the features that most effectively distinguish each land type. These features, delineated on maps, identify areas of land with different ecological dynamics. In a process sense, they convey that the contents of one unit flow into, and through those adjoining it, and that over time their biotic content can

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[162] T.F.H. Allen and Thomas W. Hoekstra (1992), 'Toward a Unified Ecology', Complexity in Ecological Systems Series, Columbia University Press, New York.

[163] R.V. O'Neill, D.L. DeAngelis, J.B. Waide, and T.F.H. Allen (1986), 'A Hierachical Concept of Ecosystems'. Princeton University Press.

[164] Warren and Cheney (1993), *ibid*.

change. These units, responsible for the maintenance of integrity and restoration, can thus be called *ecosystems.*

These must be defined relative to the spatio-temporal scale of the problem being addressed. From the top down, an ecosystem is part of the biosphere. From the bottom up, it is organisms and the communities they form interacting with one another and non-living features across a common substrate of land or water. In the contemporary New Zealand landscape, the history of agricultural land development has led to a situation in which (while forests on different types of land may be broadly similar in terms of species composition), they now vary enormously in terms of major ecosystem processes: disturbance-recovery regimes, predator-prey relationships, nutrient cycling and energy flows, etc.

For example, agriculture's highly selective historical interest in certain kinds of land has led to the situation in which in lowland and coastal country of low relief (alluvial plains, ash plains, sand flats, etc.), indigenous biodiversity is at a far greater level of alteration than it is in montane hill country and steeplands. Depending on the space-time scale used in the observational set chosen to differentiate within these land types, ecosystems could be seen as static or dynamic, steady-state or fluctuating, severely depleted or intact, fragmented or integrated. The concepts that need to be understood to make meaningful and socially relevant comparison between different ecosystems—*stability, equilibrium, decline, recovery,* the *temporary*, the *enduring*, the *threatened*, the *locally significant* and the *nationally significant*—have meaning relative to some particular scale.

Depending on the spatio-temporal scale used to differentiate these landscapes into ecosystems, the forest will be seen: (1) as a dynamic entity in its own right, (2) as a constant (i.e. non-dynamic) background within which an organism operates, or (3) as inconsequential noise in major geomorphological processes. Thus it becomes impossible to designate *the* components of *the* ecosystem. The designations will change as the spatio-temporal scale changes.[165]

8.4 BOUNDARIES

Since there are many useful ways to understand a system, articulated social goals must direct choices as to how natural systems are described.... Determining the correct scale and perspective involves a complex interaction of value definition, concept formation and scientific description—an interaction in which the articulation of environmental goals drives science. [Norton and Ulanowicz][166]

For every species, there is, at any point in time, some point in space defining where it can live and where it cannot; a boundary. Many early ecologists extended this principle to assume that species formed groupings that characterised distinct, clearly bounded types of communities. As the drawing of boundaries across the land in order to *map* nature's patterns continues to reveal, the notion hasn't really disappeared.

The best ecosystem boundaries will be those where anyone who looks at a boundary on an ecosystem map can subsequently see it on the ground expressed as a sudden and substantial shift from one pattern of life form to another.

Cases of sharp boundaries between competing species or communities of species do exist, e.g. grassland and frost flat margins where mountain beech forest suddenly meets tussock, tidal and riparian margins. But as the American ecologist Robert Whittaker has shown[167], for the most part, ecosystems, like their constituent communities, intergrade

[165] O'Neill et al., *ibid*.

[166] B.G. Norton and A. Ulanowicz (1992), Scale and Biodiversity Policy: a Hierachical Approach, *AMBIO* 21(3).

[167] Robert H. Whittaker (1975), 'Communities and Ecosystems', McMillan, 2nd edition.

continuously. There are four types of hypotheses of multiple species distributions along environmental gradients:

1. Competing species, including dominant plants, exclude one another along sharp boundaries. Thus distinct zones, or at the landscape scale, ecosystems, develop—each with its own assemblage of species, adapted to one another organisationally.
2. Competing species exclude one another along sharp boundaries but do not appear to be organised into groups with parallel distributions.
3. Competition does not, for the most part, result in sharp boundaries between species populations or communities or ecosystems. They intergrade continuously. But evolution of species toward adaptation to one another organisationally, will result in the appearance of groups of species with similar distributions.
4. Competition does not produce sharp boundaries between species, communities and ecosystems. Evolution of species in relation to one another does not produce well-defined groups of species adapted to one another organisationally.

Because ecosystems are open, because processes are emphasised rather than end points, because the concept operates at a variety of temporal and spatial scales and incorporates episodic disturbances, ecosystems boundaries can never be absolute. They are guides to the thresholds at which profound change from one organisational ecological state occurs.

9. Establishing a national framework for defining, depicting and evaluating New Zealand as ecosystems

A regional landscape approach... demands an integration of ecological evaluation methodologies, co-ordinating data from individual species occurrences to regional landscape patterns... should recognise the importance of broad corridors connecting habitat islands... Large, essentially unmanaged areas unquestionably offer the best prospects for long-term maintenance of ecosystem processes and integrity. [Reed Noss][168]

This chapter shows how we can respond to this sea change. How can we integrate both our fragmented landscape and our fragmented thinking about natural systems operating in time and nature, and begin to reintegrate human activities with the conservation of biodiversity?

9.1 LOCAL LANDSCAPE ECOLOGY AND HISTORY

Landscape ecology incorporates hierarchy theory, concerned with systems that have a certain type of organised complexity. Its application to landscape ecology lies in its provision of guidelines for defining the functional component of a system. It defines ways components at different geographic scales are related to one another; lower-level components interacting to generate higher level behaviours, and higher level behaviours controlling those at lower levels. A lower-level example might be a dune lake edge or ecotonal sequence whose ecological composition is determined by lake level. At a large scale, the lake edge is

[168] Reed F. Noss (1983), A Regional Landscape Approach to Maintain Diversity, *BioScience 33(11)*: 700–706.

related to the hydrology of the wider dune system, which at yet a larger scale is related to the hydrology of the whole catchment.

One of the best ways of evaluating the relative integrity or health of an ecosystem is by comparisons of it over time. If we are to assess the trend of change in an ecosystem, whether it is depleting, stable, collapsing or recovering, we need to know the state in which it has been. We need historical insight into it.

A contentious issue in landscape historical interpretation is the datum, or time plane at which the benchmark reference ecosystem state is constructed[169]. There are two main choices: A.D. 1840, when organised European settlement and landscape transformation began; or a date selected from the palaeoecological or archaeological evidence denoting the pre-human state. Depending on context, both time planes have meaning.

9.1.1 Ecological signatures

Simply naming a stretch of country on an ecosystem basis says little of potential or risk. In the Hurunui District, for example, a region of North Canterbury now largely transformed by agriculture, 'ecosystem signature names' have been provided to indicate both the ecosystems' natural vegetation and their underlying land type: short tussock plains, coastal flax plains, and kanuka woodland plains; matai-totara downlands, hard rock beech hills, and coastal matai-totara hills; red tussock valleys, and snow tussock ranges[170]. In a Waitakere ecological structure plan, faunal names have also been included: the 'manuka, kahu, stormy coastal hills ecosystem'; the 'puriri, kereru, warm lowlands ecosystem', etc. The names recognise key functional

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[169] K.F. O'Connor, F.B. Overmars, M.M. Ralston (1990), Land Evaluation for Nature Conservation: A Scientific Review Compiled for Application in New Zealand. *Conservation Sciences Publication 3*: 197–214. Department of Conservation, Wellington.

[170] Di Lucas (unpublished), *Landscapes of the Hurunui District*. Report to the Hurunui District Council, Lucas Associates, Christchurch, 1995.

relationships (e.g. kereru dispersing puriri seed) as well as underlying land type and bio-climatic diversity[171]. An urban Christchurch study has suggested comparative ages of land surfaces; with the 'lush, older plains ecosystem' through to the 'young plains ecosystem'[172].

Fortunately there is considerable documented connection in New Zealand between ecological processes and the land's physical form and parent material. Distinguishing ecosystem units at the Ecological District level is the better means because it is the most stable of ecosystem components and strongly controls the regional and local climate, soil moisture and related nutrient conditions to which ecosystem biotic patterns are most connected[173]. Recognising this, development of an ecosystem framework for a national biodiversity strategy has included a schedule of approximately 45 major landform types[174].

Most land-based issues relate to particular *physical* types of country, be it to do with land use type, trends of reversion to secondary forest, groundwater contamination, soil structure deterioration, or nutrient depletion. The RMA's sustainability objective, for example, can be better targeted if ecosystems are delineated and articulated in such terms as a geographic foundation for evaluating their integrity, vulnerability and resilience. An ecosystem framework that can distinguish different types of country on the basis of their propensity to potentially damaging, adverse effects of certain land use activities, from nitrate enrichment of acquifers to topsoil damage by high-country burning, is

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171 Lucas Associates (unpublished), 'Ecosystems of Waitakere'. Waitakere City Council, Henderson, 1996.

172 Lucas Associates (unpublished), *Indigenous Ecosystems of Otautahi Christchurch*, Agenda 21 Committee, Christchurch, 1995. See also Di Lucas (1996), The nature of a place, *Landscape New Zealand,* Jan/Feb., pp. 13–15.

173 G.C. Kelly and G.N. Park (1986), The New Zealand Protected Natural Areas Programme: A Scientific Focus. *NZ Biological Resources Centre Publication 4*: 23. DSIR, Wellington.

174 Working group reports on Ecosystem Classification and a Priority Setting System, Department of Conservation, Wellington, 1994.

obviously better for state-of-the-environment monitoring than one based on different climatic or vegetation cover classes.

Well-established in New Zealand and readily discernible from the New Zealand Land Resources Inventory, is the concept of the *land system*: a tract with physiographic coherence and unity in its ecological characteristics incorporating climatic and vegetation factors.[175]

9.2 CLIMATE AND ENVIRONMENTAL DOMAINS

Certainly in New Zealand, its long, narrow mountainous shape bestriding the path of global weather patterns, climate is a major contributor to environmental complexity. Strongly maritime, with pronounced altitudinal gradients and high rainfall zones and semi-arid ones less than 100 kilometres apart, it is a country in which the relationship between climate and biotic patterns is elemental. Recent research corroborates the emphasis that early ecologists put on climate as a fundamental predictor of ecosystem distribution and biotic composition.[176]

Solar radiation, temperature and moisture dominate the environmental variables that have been incorporated into the comprehensive set of tools for the prediction of priority areas for the conservation of biodiversity in Australia[177]. A preliminary classification of similar environmental data sets for New Zealand has recently divided it into groups that can be seen to respond to major vegetation classes[178].

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[175] Kelly and Park (1987), *op. cit.*

[176] C.D. Meurk (1995), Evergreen Broad-leaved Forests of New Zealand and Their Bioclimatic Definition. Pp. 151–197 *In:* E.O.Box et al., *eds*, 'Vegetation Science in Forestry.' Kluwer Academic Publishers, The Netherlands.

[177] C. Margules and T.D. Redhead (1995), 'BIORAP (Rapid Assessment of Biodiversity Priority Areas): Guidelines for Using the BIORAP Methodology and Tools'. CSIRO, Canberra, Australia.

[178] B.D. Clarkson, Landcare NZ, *pers. comm.*

While topographic variability is commonly used as a means of ecosystem discrimination, recent New Zealand studies of the relationship between vegetation patterns and environment show that altitude, a surrogate for climatic variability, is generally predominant over it[179]. However, a predictor of ecosystem type and composition is not necessarily as good a parameter of ecosystem character. These are inclined to be the commonplace features of *appearance*—patterns and changes in space which are, like land forms and major vegetation types, highly visible and recognisable in their distinguishing of one stretch of country from another.

But climate cannot always be used as an indicator. Most importantly, it doesn't provide information in a form that is so essential for regional and district state-of-the-environment reporting and its need at the local community level: simple and robust, yet easily understood[180].

Rather than providing parameters for defining ecosystem character and delineating boundaries, climate serves best as part of the componentry of 'environmental domains', a multivariate framework of environmental factors. These map climate surfaces at a range of scales. Correlating readily with indigenous vegetation they would be useful in presenting the patterns of ecological diversity within units of a national or regional ecosystem framework.

9.3 VEGETATION COVER PATTERN

For the prospect of subdividing New Zealand into ecosystems, vegetation cover appears to be the obvious course, at least to begin with. Many ecologists have classified the diversity of ecosystems in strictly vegetation terms: whether different types of primary forest or tussock grassland, or in differentiating land in pasture or exotic

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[179] B.R. Burns and J.R. Leathwick (1996), Vegetation-Environment Relationships at Waipoua Forest Sanctuary, Northland, New Zealand, *New Zealand Journal of Botany 34(1)*: 79–92.

[180] Ministry for the Environment (1996), 'National Environmental Indicators: Building a Framework for a Core Set', Wellington.

forestry plantations from indigenous forests. From the range of these studies, national classification was attempted in 1983[181]. In 1994 for a classification of New Zealand's ecosystem, a nested series of vegetation classes was compiled[182].

Strongly responsive to environmental variation, and readily discernible, vegetation cover can be excellent for identifying and discriminating representative indigenous ecosystem units. For an ecosystem framework for assessing ecosystem status and health, and for resource management and state-of-the-environment reporting, however, it does pose problems.

With New Zealand's limited range of dominant indigenous forest species, broadly similar types of vegetation can occur in widely separated and ecologically distinct districts. An ecosystem framework based strictly on vegetation, differentiating broadly different classes—say, kahikatea-pukatea forest and pasture—on the same alluvial terrace, for example, disallows any future possibility of considering them both as temporarily different states of what is in elemental physical terms, the same ecosystem. Similarly, an historical perspective, so essential to any discernment of trends of ecosystem decline, is lacking in any framework based strictly on existing vegetation cover.

9.4 OTHER OPTIONS: WATERSHEDS, AND MOBILE AND MIGRATORY KEY SPECIES

Managers will think, at various scales, of the natural forces like water flow that shape an ecosystem and determine its biotic content, what the key species like major seed dispersers actually do in their environments, what do they

[181] J.M. Owen and G.N. Park (unpublished), 'A Classification of Natural Ecosystems in New Zealand'. Report, Biological Resources Centre, DSIR, 101p., plus Appendices, 1983.

[182] C.D. Meurk and W.B. Shaw (unpublished), 'Classifying ecosystems for conservation of biodiversity' Part 2, Draft for discussion. Dept of Conservation, Wellington, 1994.

need seasonally and long-term to maintain viable populations, how far do they range in seeking it? Some will recognise that, for some species like eels and pipiwharauroa, the shining cuckoo, the necessary effective ecosystem extents over vast areas of the wider Pacific; and for some migratory waders like kuaka, the godwit, even further.

9.4.1 Watersheds

Streams are the arterial system of the land. They form a continuum of physical environments and associated aquatic and terrestrial plant and animal communities... that begins with the smallest stream and ends at the ocean.... This continuum is a longitudinally connected part of the ecosystem in which downstream processes are linked to upstream processes. [Maser and Sedell][183]

Recognition of the interconnectedness between hill slope processes and the stream channel, and downstream effects on lakes and estuaries, has led to the principle that specific physical criteria can be used to measure the state of natural life-support systems. The watershed readily builds understanding of the elemental ecosystem concepts of integrity, resilience, inter-connectedness and self-correction when subject to natural disturbance, etc. The high incidence of movement across habitat boundaries by aquatic biota argues for inter-connectedness as a key issue in ecological integrity[184]. Watersheds too provide an ideal means to remind the public of how ecosystems are primarily made up of processes. Watershed management at the ecosystem level can be far more practical for sustainable resource management than on the basis of political or jurisdictional boundaries.

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[183] Chris Maser and James R. Sedell (1994), 'From the Forest to the Sea: The Ecology of Wood in Streams, Rivers, Estuaries and Oceans'. St Lucie Press, Florida.

[184] A.P. Covich (1993), Water and Ecosystems. Pp. 40–55 *In:* P.H. Gleick, *ed.*, 'Water in Crisis', Oxford University Press, Oxford.

9.4.2 Mobile and migratory key species

Most followed food and warmth from forest to forest. Some, like kereru, tui and bellbirds, flew miles in search of a meal, completely vacating some inland valleys in winter. If their life-support systems were to be safeguarded, representative slices… would not be enough; connecting corridors would also be needed. The key pieces would be the lowland plains and basins… [Geoff Park][185]

Large home range forest birds like kaka and kereru play a key role in major forest tree dispersal. There is even measured evidence of the scale of their movements across the landscape, but little of the kind that could be used, like land physiography, vegetation cover or watersheds for ecosystem depiction and delineation.

'Greater ecosystems' herald a new ecological way of looking at environmental conservation and sustainability. Classification and evaluation of these often huge systems is quite different from that associated with land systems, vegetation types, and bioclimatic zones. The best representative example in the district may matter less than one that contributes linkage potential, resilience and successional vigour and the territory of keystone animal species to the coherence of the larger landscape.

The territory of a keystone bird species like kereru and its interactions with the seed dispersal of major forest trees creates a need for ecosystem delineation based on mobile and essentially invisible vital processes rather than the static and highly visible factors such as land physiographic units. Mountain-to-sea sequences and 'habitat islands' may cut across the static, more readily delineated ecosystem units, and like the birds and their territories, have more social, political and educational value.

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[185] Geoff Park (1995), 'Nga Uruora: The Groves of Life. Ecology and History in a New Zealand Landscape', Victoria University Press, Wellington, p. 271.

9.5 ECOSYSTEM RESTORATION

Any stretch of country, no matter how persuasive agriculture's marks, has an indwelling life force waxing or waning, which distinguishes it from any other... every bit of land, agricultural, urban, suburban, is... part of the same territory—never completely unnatural. Always restorable. [Geoff Park] [186]

Ecosystem restoration is the process of repairing damage caused by humans to the diversity and dynamics of indigenous ecosystems. It begins with a judgment that an ecosystem is damaged to the point that it will not regain its former characteristic properties in the near future (say, two generations or about 50 years), and that continued degradation may occur[187].

So often, where a forest remnant survives but its wider ecosystem's integrity has been devastated by clearance of the surrounding land, restoration is needed to meet the goal of ecosystem management. The successful restoration of a disturbed ecosystem is an *acid test* of our understanding of that system. This means creating an ecosystem indistinguishable in both structure and function from the original[188]. Of course, even remotely replicating the conditions in which the original ecosystem developed creates its own difficulties[189]. But however skilfully planted and maintained, the restored ecosystem can never be fully authentic, or as valuable as its natural counterpart[190].

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186 Geoff Park (1995), *op. cit.*, pp. 331-332.

187 Laura L. Jackson, Nikita Lopoukhine and Deborah Hillyard (1995), Ecological Restoration: A Definition and Comments. *Restoration Ecology 3(2)*: 71-75.

188 A.D. Bradshaw (1987), Restoration: an Acid Test for Ecology. *In:* W.R. Jordan, M.E. Gilpin and J.D. Aber, *eds*, 'Restoration Ecology: a synthetic approach to ecological research', Cambridge University Press.

189 Eugene P. Odum (1969), The Strategy of Ecosystem Development, *Science 164*, 18 April.

190 Eugene P. Odum (1993) The Ghosts in the Forest. *Restoration and Management Notes 11(1)*: 3.

9.6 GUIDING PRINCIPLES

1. *Efforts at maintaining biodiversity should be directed at maintaining the total diversity of the landscape as a continuum in space and in time over multiple generations.*

Landscape-level goals must be defined more precisely by increased articulation of biodiversity values within a defined local land area. Good management will require public dialogue as much as expert opinion because the definition of goals and development of scientific understanding is an interactive and experimental process.

2. *Diversity must be understood dynamically, in terms of healthy processes, including succession and response to natural episodic events, rather than merely as maintenance of current elements of the system.*

The development of landscape-level models will involve choosing a scale and a perspective from which to both understand and manage large ecological systems.

3. *Units need to be geographically delineated and their essential character and approximate boundaries readily recognisable on the ground, and meaningful in terms of a local sense of place. It is important that these are living, ecological entities in their naming and definition, as distinct from simply physical 'land systems'.*

4. *Economic activities that complement and enhance rather than oppose and degrade, natural ecological processes are to be preferred and encouraged.*

Recognising that natural systems will react creatively to change, we should develop economic incentives to encourage economic development that mimics natural disturbances[191].

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[191] After Norton and Ulanowicz (1992): Scale and Biodiversity Policy: a Hierarchical Approach, *AMBIO 21(3)*.

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