A LEEP Forward:
Biodiversity Futures for New Zealand

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We do not believe that resource management is inherently destructive, but so far the record of its effects on biodiversity is rather bleak.
(Noss & Cooperrider 1994:131)

Biodiversity decline is New Zealand's most pervasive environmental issue
(Conclusion 2. The State of New Zealand's Environment report 1997:10.6)

In the cloistered tradition of scientific specialization, most ecologists think of the world narrowly, as a system of natural environments beleaguered by human activity. They live, as Aldo Leopold put it, in a world of wounds. They have reason to think this way. Today, less than 10% of the earth's surface remains in a mostly unchanged state, and only 4% has been set aside in natural reserves. In their own speciality, planners and landscape designers tend to stay in their larger and wholly different world. For them, the bulk of the land has been given over to humanity; and now, they say, people must redesign it to their liking.

Neither view, taken to the exclusion of the other, is viable any longer... A few…have come to focus on the intellectually rich domain of overlap between the two fields. The result of their deliberate intermediacy is the new discipline of landscape ecology.
(Edward O. Wilson Foreword to *Land Mosaics* (Forman 1995).

ABSTRACT

Loss of indigenous biodiversity continues in New Zealand. Despite admirable goals in the NZBS 2000 to the contrary, efforts at improved biodiversity conservation have been insufficient to halt loss of significant amounts of indigenous forest and wildlife habitat. Increasing numbers of native species are moving towards critically endangered and extinction. Whatever we are doing in New Zealand, it is not effective enough.

The aim of this study is to firstly identify factors contributing to the failure, *"to halt the decline of indigenous biodiversity"* in New Zealand and to then consider opportunities to overcome these barriers.

In considering opportunities, this study then reviews the emerging discipline of landscape ecology as an answer to, at least, some of those factors and the recurring calls from New Zealand ecologists for a more integrated and holistic approach to biodiversity conservation. Recent advances in the planning framework and particularly provisions for biodiversity conservation in England are explored as a model of practical application of landscape ecological principles to land-use planning.

From this review, the study proposes a new 'LEEP' model for strategic biodiversity conservation that produces a regional-scale spatial conservation map and accompanying policy and implementation guide. Together they provide an integrated and holistic approach to restoring or creating functional landscapes that also recognises and provides for human activities and development. Application of the LEEP model is demonstrated through a case study of the Wellington region. Benefits and potential uses of the map and policy outputs are canvassed.

Interviews with leading New Zealand and international ecologists provide an assessment of the current status of landscape ecology and interviewees also act as an expert 'test panel' against which the Wellington maps and guides produced from the 'LEEP' model are assessed.

Finally, suggestions are provided for development of the new model and future research needs towards fuller and more effective implementation of this approach to biodiversity conservation in the New Zealand context.

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Thanks go to John Gibson, GIS Coordinator at Greater Wellington Regional Council (now DOC Hokitika), who enthusiastically developed and produced the land cover base maps. Also, Roger Smith of Geographx NZ Ltd, Wellington who produced the series of maps of past and present indigenous vegetation cover for New Zealand and the Wellington region for me, free of cost.

I am also very grateful to the staff at Karori Wildlife Sanctuary who have not only supported my work, but also permitted time for study and supervision and accommodated the many occasions when I have either been absent from work or been less available than I might otherwise. They are the true conservation heroes that are forging part of the future securing New Zealand's unique indigenous biodiversity and inspiring generations of active and armchair conservationists. I hope my work makes a difference and eventually complements theirs.

Finally to my family – Janet, Ian, Grant and Megan – apologies for the inconvenience and thanks for the tolerance as I chase my dreams. For the almost daily occasions when I was locked away in the study, researching and writing, when I might have spent more time with you, I will always be grateful.

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CHAPTER ONE – INTRODUCTION

1.1 INTRODUCTION

New Zealand is considered an international leader in conservation policy and practice efforts to protect threatened species. Yet despite a number of major national conservation and environmental policy initiatives New Zealand continues to experience a loss of indigenous biodiversity. Clearly, current conservation initiatives have proved insufficient to arrest this loss. This study builds on existing policy provisions but moves beyond traditional conservations methods to investigate and propose a new strategic approach to biodiversity conservation planning.

This chapter introduces the thesis and contains an investigation of the problem, including an analysis of the current implementation of the existing conservation policy framework. It then outlines the significance of the study, aim, scope, assumptions and the structure of the remaining chapters.

1.2 STATEMENT OF THE PROBLEM

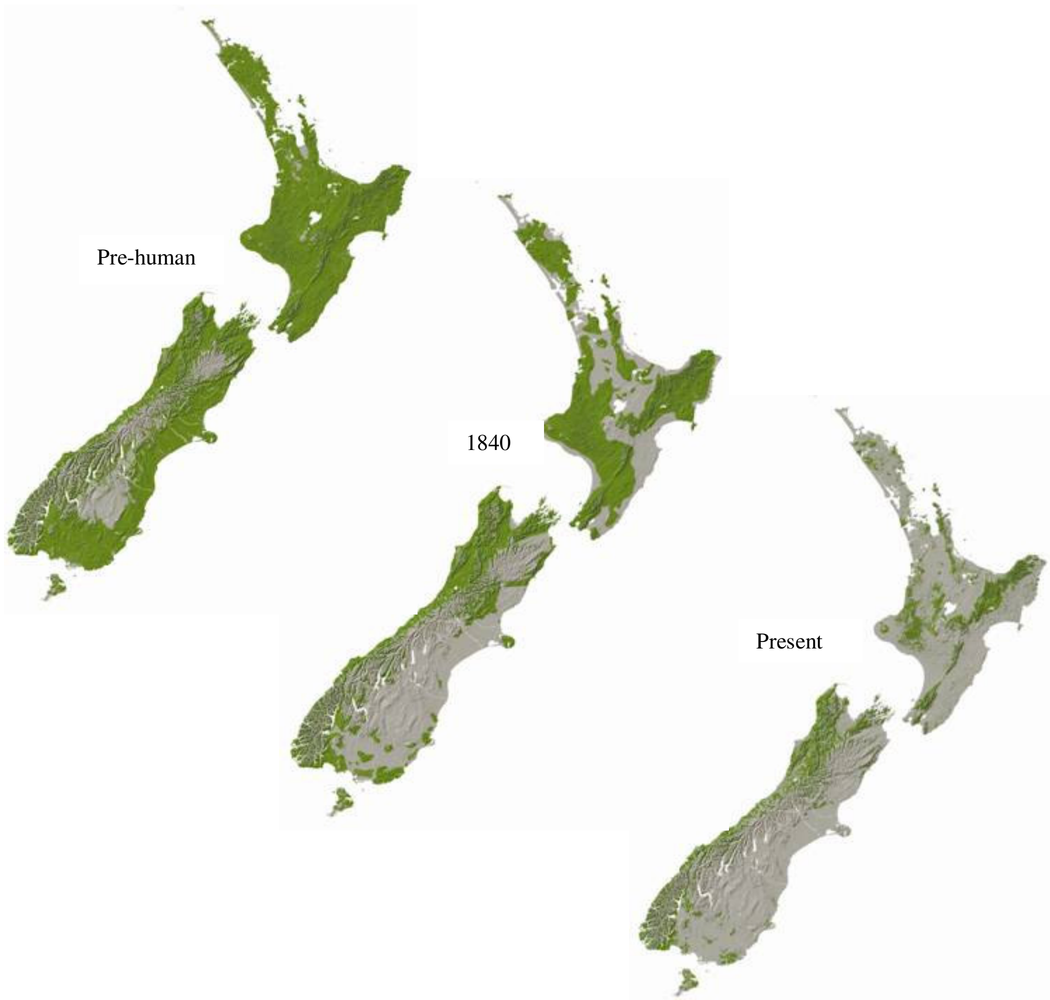
The historic loss of New Zealand biodiversity has been both dramatic and devastating. Widespread loss of indigenous vegetation cover has been accompanied by fragmentation of much of the remaining cover, loss of habitat, and loss or endangerment of unique New Zealand species.

Despite 30 percent, one-third, of the total land area of New Zealand being preserved in conservation estate, 70% of the indigenous cover and over 90% of its wetlands have been lost (Department of Conservation, 2000:4). Of the 30% protected, 75% of these protected areas by number are areas less than 50ha in size and only make up less than 1% of the protected area (Simpson, 1996: 61-62); 32% of our land and freshwater birds species and 45% of our frogs have been lost forever. Another 1000 native animals, plants and fungi are still under threat (Department of Conservation, 2000: ibid). The magnitude and significance of this loss of indigenous cover is powerfully illustrated by **Figure 1**[1].

[1] The pre-human vegetation data came mostly from predictive natural vegetation work done by Landcare Research – done using multiple regressions to couple plot-based descriptions of current forest composition with functionally based environmental predictors. Separate models were run for each of 37 widespread native species. The resulting data then underwent multivariate analysis to define forest classes. The 1840 estimates are less robust scientifically, more general in nature, and altogether less authoritative. Geographx created these by

Adding to this precarious status of our biodiversity, 38% of the remaining indigenous cover is still unprotected (Walker, Price, Rutledge, Stephens, & Lee, 2006) with most remnant patches surviving on private land. Attempts to halt this decline are represented by two streams of national environmental policy – the Resource Management Act 1991 and the New Zealand Biodiversity Strategy 2000.

Figure 1. Historic Loss of New Zealand Indigenous Forest Cover.
(Courtesy of Roger Smith & Geographx NZ Ltd, Wellington, NZ)



1.2.1 Resource Management and Environmental Planning

The Resource Management Act 1991 (RMA) is recognised internationally as leading legislation in sustainable environmental management policy. The RMA is fundamentally an

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modifying the pre-human data, based on various information and materials including plate 12 of the Historical Atlas (the East Polynesians effect on flora and fauna).

ecosystems approach to environmental management (Park, 2000:53) of privately owned land, coastal marine area and understanding the effects of people's activities on air, water and soil.

One purpose of the Act is, *"Safeguarding the life supporting capacity of … ecosystems*" (s5 (b)).

In *"Avoiding, remedying, or mitigating any adverse effects of activities on the environment"* (s5 (c)), the term 'environment' is defined by the Act to include *"Ecosystems and their constituent parts*" (s2).

In achieving the purposes of the Act, planning authorities are to have particular regard to the protection of the *"Intrinsic values of ecosystems*" (s7 (d)). The "intrinsic values" of ecosystems is defined (s.2) as *"those aspects of ecosystems and their constituent parts which have value in their own right, including (a) their biological and genetic diversity; and (b) the essential characteristics that determine an ecosystem's integrity, form, functioning, and resilience"*. The term "ecosystem" is nowhere defined in the RMA, but the Environment Court has taken the 'normal' meaning from the definition in s.2 of the Environment Act 1986 to mean *"any system of interacting terrestrial or aquatic organisms within their natural and physical environment"*. The term is used inclusively in the definition of "environment" to include *"their constituent parts, including people and communities"*.[2] Clearly, the RMA envisaged planning documents and processes taking a big-picture, ecosystems approach to environmental planning and protection.

Froude (1997), however, reviewed a representative sample of district and regional council provisions relating to protection of ecosystems and biodiversity resources, and concluded that the various approaches adopted by local authorities lacked consistency and were often *ad hoc*. My own review of planning documents for the Wellington region and its constituent local authorities suggests little has changed (see **Appendix A**). Well-meaning biodiversity work at district level remains *ad hoc*, while an intended ecosystem approach to regional biodiversity planning (Wellington Regional Council, 1995) has not been implemented (Pers.comm. Porteous & Crisp 2007).

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[2] By not providing a definition of the word "ecosystem" in the RMA, Parliament may have intended that the word be given its ordinary meaning: *RFBPS v Manawatu-Wanganui RC* A86/95 (PT), partially reported at [1996] NZRMA 241, noted [1995] BRM Gazette 145.

1.2.2 Biodiversity Conservation

The New Zealand Biodiversity Strategy (NZBS) (Department of Conservation, 2000) was prepared in response to the decline of our indigenous biodiversity and New Zealand's commitment to the international Convention on Biological Diversity (*ibid.* p.ii) and reinforced an earlier New Zealand State of the Environment Report (SOE) which concluded that, *"Biodiversity decline is New Zealand's most pervasive environmental issue."* (Ministry for the Environment, 1997:10.6).

The same SOE report identified the main threat to most species was insufficient and fragmented habitat (Ministry for the Environment, 1997:9.6). This conclusion was echoed in the NZBS which stated that biodiversity decline was a result of *"an even more pervasive loss – that of natural ecosystems and habitats… A once continuous range of unique ecosystems has been turned into a patchwork of isolated fragments" (Department of Conservation, 2000:6)*. The SOE report recognised that New Zealand's traditional response to biodiversity decline focused mainly on ecosystem and species recovery programmes on offshore islands and extensive pest control on the mainland, while restoration of indigenous ecosystems had yet to be addressed (Ministry for the Environment, 1997:10.7).

The NZBS adopted among its strategic goals, *"Halting the decline of indigenous biodiversity"*(Department of Conservation, 2000:iii and pt2.6). It identified that among the *"most pressing biodiversity issues"* for maintaining biodiversity of natural habitats outside public protected lands and the sympathetic management of indigenous biodiversity in production landscapes and seascapes, was *"restoring connections between presently isolated fragments of natural ecosystems"* (Ministry for the Environment, 1997:Pt1.9). As a result, desired outcomes for the 2020 target year included habitat and ecosystem restoration, enlarging and improving connections of fragmented habitats, and sustainable management of surrounding areas on both public and private land (Department of Conservation, 2000:33, 38-39). At the very least, the NZBS heightened a public expectation that the intentions and desires of the Strategy would be carried out or that significant steps would be made towards their achievement.

In their recent five year review of the NZBS, Green and Clarkson (2006:48-49) determined there had been mixed progress on priority actions. Protection of terrestrial ecosystems and species has been limited, particularly in lowland areas where indigenous remnants are scarcest.

A significant portion of the government's $184M Biodiversity Package funding over five years to implement key actions identified in the NZBS went on the traditional areas of animal and plant pest control and species recovery programmes (*ibid*, p.14 & 18). Green and Clarkson highlight the statement of the NZBS that restoration of habitat is closely linked to species recovery, but they concluded that due to limited resources 77% of threatened species still lack target recovery work and are *"most likely in decline"* (*ibid*, p.19).
Green and Clarkson considered that successes in some areas (e.g., use of voluntary and financial incentive mechanisms) have been offset by the loss of indigenous ecosystems, including some with high biodiversity values. This loss is perhaps best illustrated by Green and Clarkson's estimate that in the first five years of the NZBS, the overall rate of indigenous ecosystem loss has been conservatively estimated at about 4500ha per year, which equates to a loss of 28,600ha (Green & Clarkson, 2006), or an area the size of Abel Tasman National Park every five years! In a Radio New Zealand interview (15 March 2007), Green said he believed this rate of loss is continuing. In an open session at the *Conserv-vision* Conference held in Hamilton in July 2007, Green and Clarkson both confirmed that the rate of loss of indigenous cover is likely to be much higher than the 4500ha per year figure they used in their Review.

This lack of effective action to "halt the decline of indigenous biodiversity" is reflected in other conservation policy:

- In the Wellington Conservancy, despite appropriate ecological protection and restoration policies in the Conservation Management Strategy (CMS) (Department of Conservation, 1996b), few policies outside more traditional ones have been implemented (Pers.comm. Flavell and Miskelly 2007). First generation CMS were not linked to Departmental budgetary processes. As a result, CMS were never "sized"; their focus was on desirable outcomes with no consideration of the funding and human resources available to implement all desired outcomes. Each CMS was also developed in isolation from the other thirteen CMS. There were no national directions. As a result, CMS, like that for Wellington, focused on local rather than any national priorities (Pers.comm. Flavell and Miskelly 2007).

- Simpson (1997) produced a report for DOC on ecological restoration opportunities in the Wellington Conservancy based on landscape ecological principles. The report offered a suite of practical recommendations that were, however, never actioned. The failure to implement was due to a lack of resources and other higher priorities hinted at in the foreword to the report and confirmed by Simpson (Pers.comm. 2007).

- Park (2000) reported on the need for the Department of Conservation to develop an ecosystem or landscape ecology approach to biodiversity conservation in New Zealand. Reflecting on the need for an ecosystem approach to conservation in New Zealand, Park pondered why, *"despite New Zealand's environmental and conservation legislation, ecologists have such difficulty in persuading conservation policy-makers to focus on <u>threatened ecosystems</u>?"* (Park, 2000:22. Emphasis Park). This report has not been acted on either (Pers.comm., Park 2007).

- Finally, in May of this year, the long-anticipated National Policy Statement on Biodiversity signalled in the NZBS and whose urgent need was reinforced by Green & Clarkson's (2006) Review, has now been abandoned by MfE and DOC. It has been 'replaced' instead by a *'Statement of National Priorities for Protecting Rare and threatened Biodiversity on Private Land'* (Ministry for the Environment & Department of Conservation, 2007). Discussions at the *Conserv-Vision* Conference held in Hamilton July 2007 indicate that the Statement falls far short of the expectations set by the NZBS and is unlikely to achieve the arrest of biodiversity decline sought. It could be argued that the Statement has a number of inadequacies that include:

  a. Reinforcing existing 'fragmented' ecosystem management by the Statement's scope being restricted to terrestrial systems and private land
  b. Continuing ecosystem isolation and fragmentation through a focus on habitats and ecosystem "types" rather than a landscape-scale or ecosystem approach
  c. Lacking any mandatory requirement for regional and local authorities to implement
  d. Failing to promote a holistic strategic approach to national, regional and local biodiversity conservation, despite setting out priority land environment units and species to protect
  e. Applying a 20% threshold for remaining indigenous cover that only applies at the national level. While this gives a picture of national rarity, the significance of the same unit at regional and local scale will widely differ. At best, the 20% threshold

priority provides another conservation tool for districts and regions, but will need further interpretation by councils

f. Seeking only to protect existing habitat and species under threat and not addressing the critical need to consider enhancement and restoration opportunities. The 20% indigenous vegetation cover threshold is 'static', only dealing with what exists and not what is possible to enhance
g. Prioritising a 20% land environments threshold that does not recognise that not all threatened classes are 'created equal', some will be more critical in local and regional contexts than others
h. Failing to address the essential dynamic and large-scale nature of many ecosystems, so prominent in the NZBS, and the need to protect or restore functional biological systems
i. Focusing on local authority implementation that will promote continued *ad hoc* biodiversity conservation effort in the absence of any national or regional strategic biodiversity conservation guidelines.
j. Failure to promote functional ecosystems and the conservation opportunities offered by multiple-use landscapes.

This diminished policy initiative seems to repeat an ongoing ignorance or unwillingness to recognise an incessant call for a different kind of strategic biodiversity planning - a comprehensive and integrated ecosystem or landscape ecology approach.
New Zealand's experience of continued loss of its ever declining biodiversity is at least part attributable to the successive failure to heed expert advice and better implement RMA provisions and NZBS action points. Reasons for this ongoing lack of policy implementation suggested by different authors is summarised in **Table 1**.

It is clear that the causes of a lack of implementation of biodiversity policy are numerous and complex – warranting research of its own. However, this study proposes a model that seeks to overcome a number of these gaps in implementation and provide a strategic approach to biodiversity conservation and increased conservation outcomes.

Table 1: Reasons for Lack of Biodiversity Policy Implementation

- Lack of national and regional policy framework, practical guidelines or standards resulting in an absence of any regional coherent strategic biodiversity planning; an absence of resourcing priorities, and; a fragmented and ad hoc application at local level
- An inability to deal with ecosystems across public and private boundaries
- Lack of appropriate social and ecological expertise, capacity or priority in environmental and conservation agencies
- Lack of vision and commitment at all levels of government
- Lack of leadership or of any biodiversity conservation 'champion'
- A continuing focus on solely a 'scientific' approach to biodiversity planning rather than integration with a spatial planning approach
- Significantly increased legal, social and political complexities involved in moving beyond existing conservation boundaries
- Difficulty in defining and uncertainties involved in ecosystem dynamics requiring perceived arbitrary judgement
- Ecosystems are biologically complex and therefore difficult to manage
- Insufficient understanding of New Zealand ecosystems and consequent reluctance to committing funding to manage poorly understood systems
- Inadequate public knowledge of ecosystems that would generate goodwill and political favour
- Pervasiveness of introduced species makes conservation unfeasible
- Ecosystem management cannot produce the tangible results of single-species recovery programmes, despite potential long-term cost benefits
- Difficulty in overcoming traditional inertia of responsible institutions
- Other priorities and limited resources
- Landowner resistance fearing further loss of property rights
- The limitations of New Zealand's traditional 'reserves-based' approach to conservation
- Conservation is most difficult to achieve in coastal lowland landscapes where conservation needs are most pressing

Sources: Park 2000:22; Pers.comm. John Craig 2006; Foreword to Simpson 1997; Pers.comm. Tim Porteous 2007; Freeman 2003:183-184.

1.3 SIGNIFICANCE OF THIS RESEARCH

The significance of this research is that it explores other ways to achieve biodiversity conservation objectives more strategically. The research will enable planners to:

- Understand the various types of problems regarding biodiversity conservation and identify a range of solutions

- Bridge the gap between science and planning and between policy, rhetoric and implementation
- Provide a platform/framework for drawing together critical but largely disparate expertise, data and human and financial effort into a more comprehensive, prioritised and dynamic approach to biodiversity conservation planning
- Provide a relatively easily understood strategic spatial plan to communicate and inspire a broad range of stakeholders, enable greater public recruitment in conservation activity and produce more sustainable biodiversity outcomes
- Promote an ecosystem approach to biodiversity conservation and eliminate the divide between protection of conservation values on public and private land, and the artificial distinction between conservation and 'productive' lands and conservation and modified landscape elements
- Provide vision, leadership and new impetus for biodiversity conservation in the New Zealand context

Given that loss of indigenous biodiversity is described by the NZBS as New Zealand's "most pervasive environmental issue", it has had a surprisingly low profile at the national and political level since then. The outcome of this study can provide a tool, used properly, to improve the profile, general understanding, and enthusiasm for public and private conservation activity. This would be in keeping with the desired outcomes of the RMA, the NZBS and the 'New Strategic Direction' of the Department of Conservation (Department of Conservation, 2006a).

The results of this study will be useful for planners and conservation scientists, national, regional and local resource managers, government, NGOs, communities and private landowners. Though the study is specific to New Zealand, the results are readily applicable to other conservation contexts because the principles and potential applications are largely universal.

1.4 AIM OF STUDY

The aim of this study is to develop an improved strategic planning approach for biodiversity conservation using examples from international theory and practice to provide suggestions for this improvement. To achieve this, the specific objectives of the study are four-fold:

1. **Define the problem**. To understand the nature and cause of past and continuing loss of New Zealand's biodiversity, particularly in relation to the two most significant policy frameworks affecting biodiversity conservation in New Zealand.
2. **Explore alternative approaches**. A review of international and New Zealand literature to identify trends and possible alternatives to long-term sustainable approaches to biodiversity conservation.
3. **Develop a new model/framework**. A new model for strategic conservation planning - the 'LEEP' model – is developed and described based on emergent theory and practice, international experience and the New Zealand context.
4. **Demonstrate application through a New Zealand case study.** The Wellington region is used to demonstrate and illustrate application of the LEEP model and its potential uses.

Each of these objectives is defined from an environmental planning perspective (rather than a purely ecological one) informed by principles of the emergent discipline of landscape ecology.

1.5 METHODOLOGY

There are several aspects to the methodology applied to explore and resolve the problem defined by this work. Firstly, two literature reviews are used to underpin the development of the LEEP model. The first review concerns literature describing and defining the emergent discipline of landscape ecology. The author believes this discipline has had limited application in New Zealand while experiencing widespread acceptance in international scientific literature and increasing application at the international level. However, application of landscape ecology and its associated principles has great potential to address a number of philosophical and practical barriers confronting biodiversity conservation n New Zealand. The second literature review is of the English biodiversity planning system which is seen as an excellent model for the application of landscape ecology in a national planning framework. This recent development has already produced numbers of policy documents, guidelines, methodology reviews, regional plans and biodiversity resource data, all available online through investment in highly accessible, user-friendly, e-planning infrastructure and documentation. Both aspects of this literature review provide the theoretical and practical basis for the strategic biodiversity conservation model developed and applied by the author.

Secondly, document analysis of the relevant planning reports generated by the Wellington Regional Council and the eight constituent local authorities to review their provisions for biodiversity/ecology. This involved reviewing the biodiversity section of the Wellington Regional Policy Statement (Wellington Regional Council, 1995) and the biodiversity/ecology sections of the eight district plans within the Wellington region – Wellington City (Wellington City Council, 2000), Porirua City (Porirua City Council, 1999), Kapiti Coast (Kapiti Coast District Council, undated), Lower Hutt City (Lower Hutt City, 2004), Upper Hutt City (Upper Hutt City Council, undated), and the recent combined plan for the South Wairarapa, Carterton and Masterton districts (Combined Wairarapa Districts, 2006). Details of policy provisions in each of these documents are provided in **Appendix A**. Other relevant Wellington City planning documents that were reviewed included the Outer Green Belt Management Plan (Wellington City Council, 2004), the Environmental Strategy (Wellington City Council, 2006b) and the Draft Biodiversity Action Plan (Wellington City Council, 2007).

Thirdly, various other resources were developed or used in resolving the problem defined by this research including:

- The development of a GIS base map, with GWRC assistance, for a regional case study. This required adapting and simplifying vegetation cover classes from the most recent Land Cover Database (LCDB2) for the Wellington region. This map is then used as the 'base map' to produce a regional ecological network map and then a strategic biodiversity conservation map with associated policy.
- A case study based on the Wellington region to illustrate how the new 'LEEP' model for strategic biodiversity conservation may be applied at a regional level within New Zealand.
- Interviews, whose purpose is to validate and inform the model in three ways:
    a. Provide current international understanding and approaches to landscape-scale, strategic biodiversity planning.
    b. Provide some New Zealand understanding about the application of landscape ecological approaches in our landscape.
    c. 'Test' the Wellington application of the LEEP Model to identify strengths and weaknesses of the model based on their experience and possible improvements.

    These interviews involved a semi-structured approach to questioning that allowed the interviewees to expand on their views on the matters addressed in this thesis. Approval for these interviews was sought and judged by the Massey University Human Ethics Committee (MUHEC) as 'Low Risk Research Involving Human Participants'. **Appendix B** lists the broad questions asked of interviewees and lists interviewees along with a summary of their responses to questions.

1.6 LIMITS OF STUDY

Biodiversity planning covers a wide range of disciplines, relationships, spatial territories, ecosystems and scales that are beyond the scope of this thesis to cover them all equally adequately. To keep this study manageable, its focus has been restricted to a number of key parameters and issues, though it may cursorily touch on some of these issues. Specifically, the scope of this study has been limited to the following:

Terrestrial biodiversity. The principles discussed and the model proposed can be just as effectively applied to aquatic, coastal and marine environments. However, the current study is restricted to terrestrial scenarios as a distinct natural environment and to address the other environments would have significantly expanded the project beyond the scope of a Masters thesis. Lake and riverine habitat is referred to in this thesis as potential critical habitat or ecolinkages, but this only relates to riverbanks and wetland habitat and not the sub-aquatic environment.

Regional scale. Scale is an important factor in biodiversity planning. The principles and model developed in this thesis may be applied at a local, regional, national and international scale. The case study focuses on the regional scale as this is considered one of the critical gaps in biodiversity planning and implementation in New Zealand at the moment. Most existing biodiversity work already occurs at the local level, albeit in an *adhoc* manner. While a national spatial biodiversity framework is desirable and could be developed from readily available information from overseas and in New Zealand, none-the-less this work has yet to be undertaken. A regional approach has direct benefits for local planning and may also be extended to provide a national and international strategy.

Wellington region. The Wellington Region was chosen for the case study for a number of reasons:

1. The Wellington Region is a natural geographic unit
2. The Region is familiar to the author and the ready availability of data and local expertise

3. The Wellington Region is representative of other New Zealand regions and geographic units from a number of perspectives:

    a. Natural and human settlement history – the processes of evolution, modification by human activity and biodiversity conservation challenges are similar
    b. Administrative issues relating to cross-boundary matters, government agencies, communities, landowners and sectoral interests are common to all regions
    c. The Region contains a mix of private and significant public conservation land
    d. The Region also contains a mix of natural, highly modified and urban environments.

Topic limits. Though significant or potentially significant, a number of topics relevant to any comprehensive consideration of strategic biodiversity are not dealt with or mentioned only in brief terms as they are beyond the scope of the current study, beyond the expertise or intent of the author, or would require their own significant research. Topics specifically excluded include:

1. **Climate change** details and their impacts on biodiversity. Though the magnitude of change and its impact on the New Zealand climate are debated (e.g. pers.comm Matt McGlone as key note speaker at the New Zealand *Conserv-Vision* Conference 2007), it does seem likely that sea level rise will impact coastal habitats and that regional climate changes will occur. The model proposed in this thesis recognises and accommodates potential for large scale biodiversity movement in response to national and regional climate change.
2. **Plant and animal pests**. Invasive species are a major threat to indigenous biodiversity and one of the two main contributors to loss of indigenous biodiversity (Department of Conservation, 2000). The requirements of invasive species management and the limitations they impose should inform more detailed analysis of the high-level strategic biodiversity conservation model presented in this thesis, but does not form part of the focus of this study.
3. **Individual indigenous species ecologies**. This study approaches biodiversity conservation from a planning perspective rather than a purely ecological one. This

study is also interested in an ecosystem approach to biodiversity planning rather than the traditional species by species approach. Assumptions about indigenous species behaviour and preferences are drawn from the review of literature on landscape ecology and the broads principles derived have been tested by experts in the fields of ecology, conservation biology or landscape ecology. But it is not intended to focus on the specific needs of individual species.

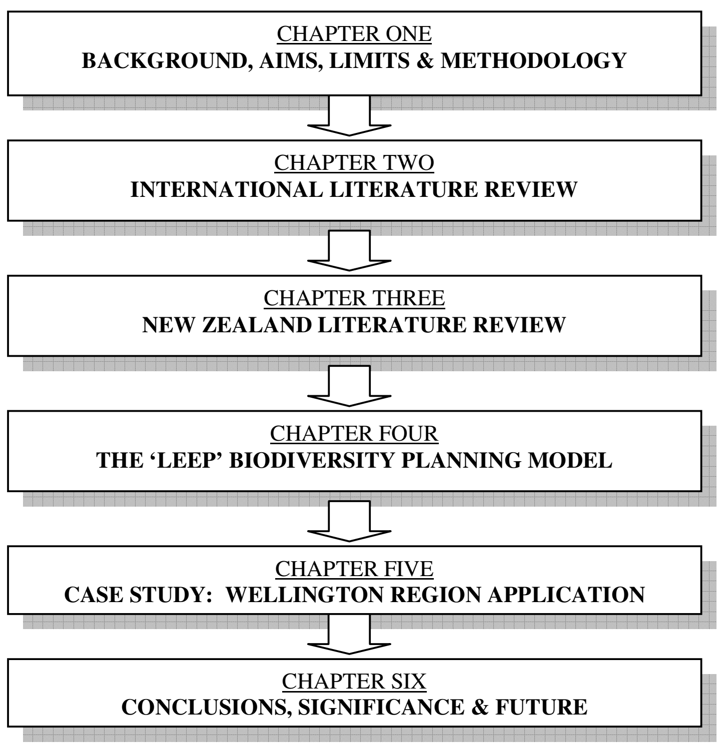
4. **RMA details**. The RMA framework and requirements are not the focus of this high-level policy development approach to biodiversity planning. Formal planning instruments are only one tool for implementing any sustainable biodiversity conservation policy at local and regional level, albeit an important one for achieving conservation gains on private land.
5. **Iwi consultation**. For the purposes of this study indigenous (Maori) input/approach/participation is not discussed or canvassed at this conceptual level of planning. However, it is recognised that *tangata whenua* as critical partners in any future detailed application beyond the high-level modelling demonstrated in this thesis. However, the approach proposed is not inconsistent with Maori values and aspirations for the natural environment, protection of natural *taonga* and the maintenance or restoration of the *mauri* (life force) of indigenous systems. Because of their traditional holistic approach to the natural environment, Maori, and more particularly the *tangata whenua* of regional New Zealand may be a significant force in the adoption and promotion of the approach proposed by this thesis. However, this remains to be tested through partnership and dialogue.
6. **International applications**. Transnational or international biodiversity conservation needs can be accommodated by the LEEP model proposed but are not a focus of the current research.

1.7 STRUCTURE OF THESIS

Diagram 1 outlines the six chapters of this thesis. **Chapter One** defines persistent problems confronting effective biodiversity conservation implementation in New Zealand. It also outlines the aims, limits and significance of the study and the methodology by which a solution is found. **Chapter Two** explores the international and national literature on landscape ecology, the English biodiversity conservation planning framework, and interviews of international and local expertise on the current status of landscape ecology. These provide the foundations for the new strategic biodiversity conservation model this study proposes.

Chapter Three reviews the New Zealand literature on landscape ecology and ecosystem planning and sets the New Zealand context for the new 'LEEP' model for biodiversity planning proposed and described in **Chapter Four** and identifies a broad range of potential uses for these maps. **Chapter Five** applies the new 'LEEP model' to the New Zealand context with an illustrative case study using the Wellington region. The chapter provides a step-by-step process for developing a strategic biodiversity conservation map and an accompanying policy implementation guideline. It also summarises some of the key implications of the model and maps for the relevant environmental agencies in the Wellington region. Finally, **Chapter Six** provides conclusions about the study that cover the importance of the LEEP model, the potential development of the model in the future, outlines the contribution of the thesis and finally identifies future research needs stemming from this thesis and which will further refine processes, outputs and outcomes.

Diagram 1 – Structure of Thesis



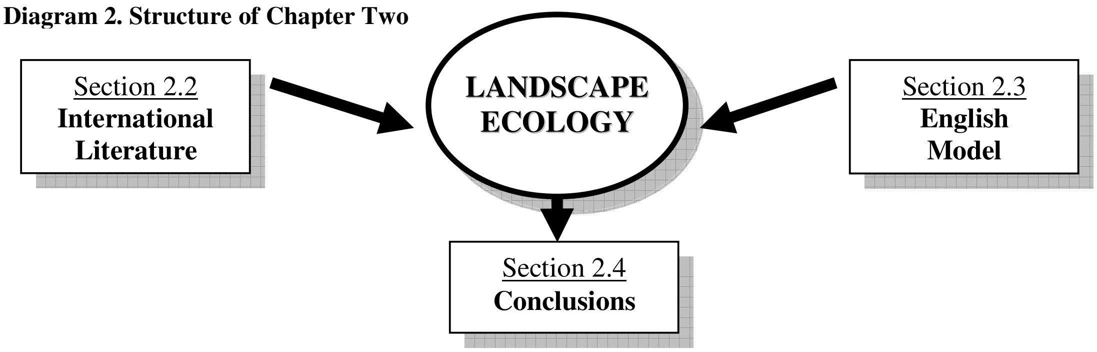
CHAPTER TWO – INTERNATIONAL LITERATURE REVIEW

2.1 INTRODUCTION

The last twenty years has produced a growing body of literature from the emergent discipline of landscape ecology. This literature has developed from the theory and experience of the only slightly older disciplines of ecology and conservation biology. Landscape ecology has been promoted by conservation organisations, universities and individual professionals, and embraced by numbers of governments as an holistic approach to strategic conservation planning. However, the landscape ecology approach is largely neglected in New Zealand conservation planning theory and practice.

This literature review begins with an examination of the development and fundamentals of landscape ecology, its essential spatial components, through to its current principles, practice and global application. **Section 2.2** also offers a summary of interviews from leading landscape ecologists on the current status of landscape ecology. **Section 2.3** provides a closer examination of the relatively new English planning framework for biodiversity conservation as a model for biodiversity conservation and extensive application of a landscape ecology approach to land-use policy and planning. Finally, **Section 2.4** draws broad conclusions about the application of landscape ecology at the international level – as a precursor to **Chapters 4 and 5** that develop and apply, respectively a new LEEP model for strategic biodiversity planning in the New Zealand context. **Diagram 2** illustrates the structure of **Chapter Two**.

Diagram 2. Structure of Chapter Two



2.2 LANDSCAPE ECOLOGY

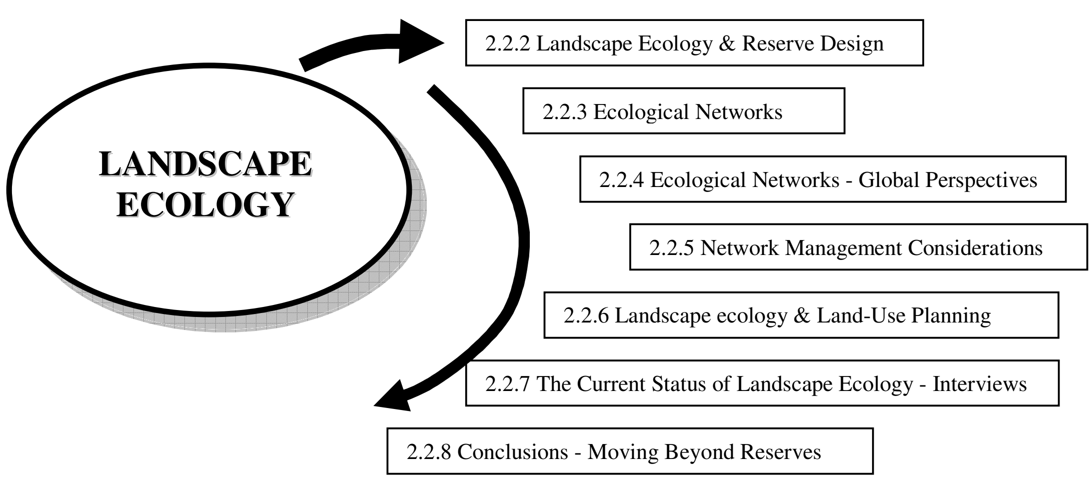
2.2.1 INTRODUCTION

Landscape ecology is an emerging discipline that embraces an overlap between the two fields of ecology and land-use planning and that spatial patterns have an important influence on landscape functionality. As such, it is an integrative and multi-disciplinary science. It also integrates humans and natural ecosystems and brings a spatial perspective to planning areas such as natural resource management, conservation and urban planning, previously guided by planning documents.

Landscape ecology encourages new ways of thinking about natural and human-dominated ecosystems (Forman, 1997:xiii; Slocombe, 1995:56). Poiani & Richter (1999) describe landscape ecology as a paradigm shift, or "new vision", in conservation planning representing as it does a shift from conservation based on rarity to one based on ecosystem- and landscape-level concepts and a greater emphasis on conserving ecological processes and functional landscapes to, *"dramatically improve… efficiency and effectiveness"* of conservation outcomes. A fundamental understanding in landscape ecology is that by saving ecosystems, you save the species and habitats within those ecosystems.

The historic roots of landscape ecology are found in traditional nature reserve design (Noss & Cooperrider, 1994; Soule & Terborgh, 1999), which are, in many ways, far from its modern counterpart. The following sections trace some of this historic development of the landscape ecology discipline while addressing different elements that inform landscape ecological thinking and provide the basis for a framework for nature reserve design. **Diagram 3** illustrated the structure of this section.

Diagram 3. Structure of International Literature Review for Landscape Ecology



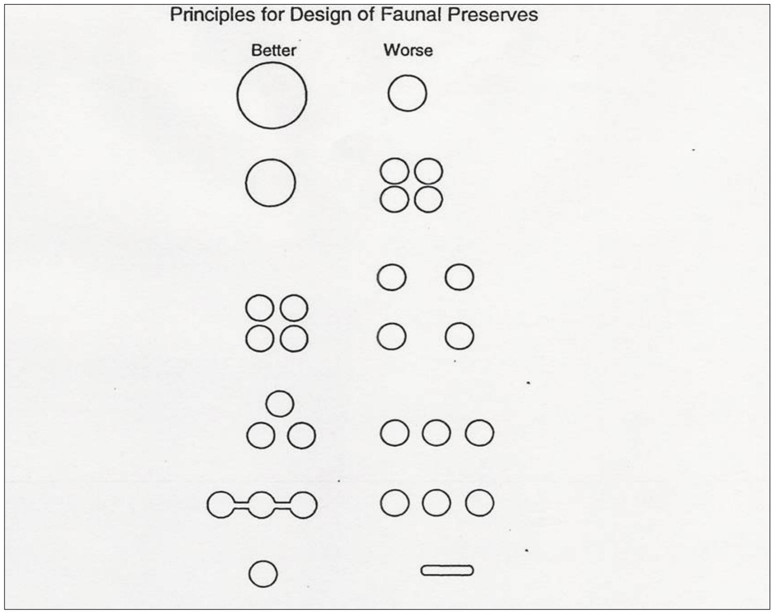
2.2.2 LANDSCAPE ECOLOGY AND RESERVE DESIGN

Reserve design represents an understanding of landscape elements and their spatial relationships. The last 30 years have seen a significant development in that understanding. **Appendix C** provides a fuller literature review of the key international authors and fundamental concepts in landscape ecology and reserve design. The review also contains personal comments from interviews with leading landscape ecologists on the current status of landscape ecology and the design of ecological networks. This section is a summary of those concepts and authors and essential background to applications made later in this thesis.

In the late 1800s, the original reserves and national parks were established to protect scenery, not wildlife habitat or ecosystems (Noss & Cooperrider, 1994). It now known that many ecosystems extend beyond human-made boundaries, and that world wide most traditionally designed reserves are too small to provide for the full needs of the species they contain (Nelson, 1993; Noss, 1990; Noss & Cooperrider, 1994) and have major boundary issues (Schonewald-Cox & Bayless, 1986). Human activities on the edge of nature reserves and the surrounding landscape have impacts on reserve edges and the larger biological systems. The discipline of conservation biology is only slightly older than landscape ecology, but together they have produced insights for a more scientific basis for reserve design, particularly at the large, regional scale (Noss & Cooperrider, 1994).

Among the earliest insights was that size and proximity of remnant areas of indigenous forest or habitat affected the level and viability of biodiversity within those areas. The equilibrium theory of island biogeographic theory (MacArthur & Wilson, 1963, 1967) predicted that large islands close to a source of colonist species would have the highest levels of biodiversity. The theory was extended to terrestrial ‘islands’ or patches in modified landscapes (Diamond, 1975; Diamond & May, 1976) and eventually led to a major challenge in the 1970s to traditional approaches in conservation science and strengthened the biological basis for reserve design (Noss & Cooperrider, 1994:138). Since then a range of ‘rules’ has evolved from experience and research that guides contemporary landscape ecology and the design of functional ecological landscapes. Diamond (1975) produced the earliest set of rules and reproduced in **Figure 2**.

Figure 2. **Original Principles for the Design of Nature Reserves** (From Diamond (1975)). For each comparison, the design on the left is considered better for maintaining species diversity than the design on the right



These rules translate to:

- Large reserves are better than small reserves.
- A single large reserve is better than a group of small ones of equivalent total area.
- Reserves close together are better than reserves far apart.
- Round reserves are better than long, thin ones.
- Reserves clustered compactly are better than reserves in a line.
- Reserves connected by corridors are better than unconnected reserves.

Where 'better' means providing more and more sustainable biodiversity outcomes. These classic rules are still considered the best generalisation of rules for reserve design (Wilcove & Murphy, 1991 & pers.comm. Forman 2006).

Ecological connectivity has been established as a fundamental concept in landscape ecology and functional landscape design (Crooks & Sanjayan, 2006; Forman, 1995; Forman & Godron, 1986; Hilty, Lidicker Jr., & Merenlender, 2006). Studies have shown that many animals use corridors when moving through developed (mostly agricultural) landscapes (Wegner & Merriam, 1979), that corridors can improve the persistence of populations (Fahrig & Merriam, 1985; Henderson, Merriam, & Wegner, 1985), and suggested that a network of patches or woodlots may promote persistence of many species in such landscapes (Noss &

Cooperrider, 1994:144). Corridors have been accepted as a legitimate tool for reserve design and reconnecting fragmented landscapes since early debates over the merits of ecological corridors have been resolved (Pers.comm. Noss and Simberloff 2006). The literature now recognises several types of ecological linkages or ecolinks and summarised in **Table 2**.

Table 2: Common Types of Ecological Linkages

Linkage Type	Characteristics & Value
CONTINUOUS	
Landscape linkages	• Large scale, major habitat links at the landscape or regional scale • Substantial areas of habitat measured in kilometres and connecting distances measured in kilometres to tens of kilometres or more. Can include major river systems • Their connectivity function and significance in ecological processes are often not recognised
Riparian corridors	• Form a hierarchy of natural linear habitat through landscapes • Supports a zone of vegetation usually structurally & floristically distinct from adjacent habitats with which it intergrades • Can have critical role and major effect on regional biodiversity • Often persist as remnant linear habitat in heavily disturbed environments
Hedgerows & fencerows	• Diverse group of rectilinear network of vegetated habitat in rural environments • Frequently provide links between remaining natural and semi-natural habitats • Seldom support sustainable populations of threatened species without forming networks together with remnant natural habitats • Significant potential role in enhancing biodiversity in rural environments
Roadside Corridors	• Occupy significant and strategic areas of land and are one of the largest and most extensive functioning systems of linear habitat on Earth • Have a significant negative ecological effect, (barrier, mortality source, disturbance) but their structural connectivity can also be strategically advantageous as roadside habitat • The wider and more suitable roadside verge the more habitat and more value in conservation
Forest linkages	• Retention of unlogged areas of forests as wildlife corridors and habitat strips • Often coincide with riparian buffer strips & may include links between adjacent catchments.
DISCONTINUOUS	
Stepping stone patches	• A significant factor in achieving functional connectivity for many species. • Enable short moves through disturbed environments where connectivity is achieved by a series of short ‘hops’ from stepping stone to stepping stone along the length of a linkage. • Suit mobile species & those tolerant of modified landscapes but unable to live in them • They may be natural stepping stones (e.g., a chain of wetlands and small remnants) or human (e.g. plantation, artificial ponds or urban parks across towns and cities).
Migratory stopovers	• Critical locations on migratory routes facilitating movement of individuals between breeding and wintering areas.
Habitat mosaics	• A mosaic describes the pattern of patches, corridors and matrix (& roads, farms & towns) that form a landscape in its entirety while a network is an interconnected system of corridors. • Parts of the mosaic will be suitable for a particular species to live in, other parts may be unsuitable to live in but do not inhibit movements, while some parts may be relatively inhospitable.

(**Sources**: A. F. Bennett, 2003; Forman, 1995; Forman & Baudry, 1984; Forman et al., 2003:97-122; Harris, 1984; Manning, Fischer, & Lindenmayer, 2006; Radford, Bennett, & MacRaild, 2004)

Ecolinkages provide four functions listed in **Table 3** and their significance is increased by their ability to facilitate adaptation and migration in response to climate change and the suggested development of ecolinks along major bioclimatic gradients (Hobbs & Hopkins, 1991).

Table 3. Types of Connectivity Function

Function	Characteristics
Habitat	• Naturally linear habitat • Important to protect, even if they have limited value as movement corridors • Have other ecological values (rich soils, high biological productivity, microclimates, abundant insect and plant food, while vegetation and substrates act as nests) • Wide protected linkages act as extensions of core reserves
Home range movement	• Function most associated with corridors • A core reserve may not include a daily or single annual home range of a larger species. • Maintaining safe movement opportunities when moving about home range on a daily or seasonal basis is a matter of protecting species from human interference and road mortality. • Minimising mortality sources – human activity, internal corridor fragmentation, predation – should be a major concern in corridor design for target species
Dispersal	• Dispersal may counteract isolating effects of habitat fragmentation, only if sufficient dispersal habitat remains. • Persistence regional metapopulation species requires enough individuals to move between patches to balance extirpation from local patches. Metapopulation persistence may increase through preserving natural linkages. • Successful dispersal is more likely when linkage habitat is similar to species living habitat. • Linkages that support resident populations are more likely to function as long-distance dispersal conduits for those species and increase the chance of gene flow in both directions. • Stepping stone habitats – none separated by impenetrable barriers or distances greater than those commonly traversed – can also be acceptable as effective corridors. • Long-distance dispersal corridor design must consider the entire life history needs of species. Considered prudent to maintain or establish wide habitat corridors whenever linking areas farther apart than normal juvenile dispersal distances.
Long-distance range shifts	• Provide for long-distance migration of species in response to climate change. • Global warming models predict relatively rapid shifts in habitat conditions in most regions. • A 3°C rise in average global temperature will result in a 250km lateral and 500m altitudinal shift in environmental ranges (Noss & Cooperrider, 1994:156). • Even with ideal corridors, many species will be unable to migrate fast enough. High extinction risks to species with limited and discontinuous distributions or poor dispersal capacities are at high risk of extinction • Maintenance of environmental gradients is best way to assist adaptive migration in response to climate change is to maintain intact environmental gradients.

(**Sources**: Beier & Loe, 1992; den Boer, 1981; Flannery, 2005; Noss, 1987a, 2006; Noss & Cooperrider, 1994; Simberloff & Cox, 1987; Soule, 1991; Soule & Gilpin, 1991; Weins, 1989)

Ecolinkages also provide a range of environmental services that influence public policy areas listed in **Table 4**. This list of potential ecosystem services demonstrates the importance of ecolinkages beyond simply their intrinsic value and promotes their protection or development as having direct social, physical and economic benefit to human interests. These environmental services are becoming critical in effectively promoting or justifying the development of ecolinkages to politicians and communities (Pers.comm. Bennett 2006).

Table 4. Environmental Services and Six Areas of Public Policy Influenced by Natural Corridors

Public Policy Area	Issue
1. Biodiversity Management	• Habitat for plant and animal populations • Refuge for populations in harsh environments • Conservation of rare species • Movement for wide-ranging species • Dispersal between isolated populations • Maintenance of ecological processes
2. Water resources	• Surface drainage patterns • Ground water recharge • Flood mitigation and control • Sedimentation and holding capacity of dams and reservoirs • Water quality and temperature • Nutrient levels and eutrophication
3. Agriculture and timber production	• Soil erosion by wind and water • Windbreaks for crops, pasture and livestock • Ground water levels and condition • Firewood and timber production • Fruits, berries and other natural produce
4. Recreation	• Wildlife observation • Hunting and fishing • Tramping, camping and recreational use • Landscape aesthetics
5. Community and cultural cohesion	• Cultural identity of rural or suburban landscapes • Links with historical land use • Privacy and property boundaries
6. Climate change	• Pathway for redistribution of populations • Habitat for species with limited dispersal ability

(**Sources**: A. F. Bennett, 2003:99; Forman, 1991:81)

Theory and experience show that ecolinkages, particularly corridors, have to be as wide as possible to minimise the ‘edge effect’ through which the effects of human-dominated landscapes impact corridors and remnant patches (A. F. Bennett, 2003:134-140). **Table 5** summarises the main types of edge effects.

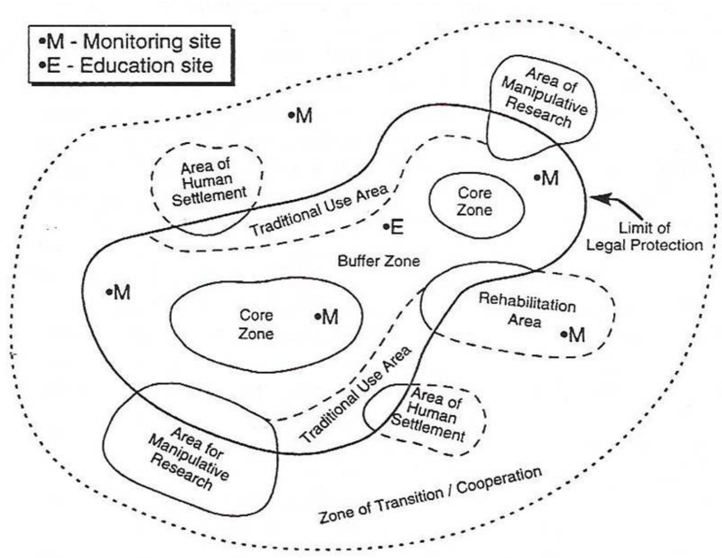
Table 5. Five Main Types of Edge Effect.

Type	Comment
Microclimates	Involve the effect of solar radiation, light, humidity, temperature and wind speed Consequently, newly created edges following exposure from clearing is likely to cause changes.
Plant community composition and structure	Edge plant communities are characteristically different from the interior. This arises from plant species responses to altered micro-climate conditions, and from invasion by plant species from adjacent habitat that also tend to displace native plants.
Altered fauna habitat	Changes in plant communities means altered fauna habitat. This may benefit some species and be disadvantageous to others.
Thriving edge specialists	Species that are edge specialists or are typical of disturbed lands can invade and become predators, competitors or parasites of 'interior' species.
Adjacent land use impacts	Edge habitat is prone to disturbance processes from activities in adjacent land. This may include drift from fertiliser and other farm chemicals, impacts of stock grazing, fires, placement of access tracks and control burns along edges, and recreational disturbance and littering
	(**Source**: A. F. Bennett, 2003:134-136; Forman & Godron, 1986; Lindenmayer, Crane, & Michael, 2005:114).

Buffer zones around core areas and corridors have become an accepted tool for overcoming edge effects and boundary issues and to promote the integration of conservation and human activities. Studies of problems around reserve boundaries (Buechner, 1987; Dasmann, 1988; Schonewald-Cox, 1988; Schonewald-Cox & Bayless, 1986) have emphasised the value of large areas and well-managed buffer zones. A major contribution to the integration of reserves with their surroundings was the development of the biosphere reserve model with the UNESCO 'Man and the Biosphere' (MAB) program (UNESCO, 1974) which recognised the need to include human needs, and particularly those of local communities, as part of the conservation context in order to achieve sustainable outcomes (Noss & Cooperrider, 1994: 142).

The basic biosphere model shown in **Figure 3** consists of protected core surrounded by one or more transitional zones. This zoning concept allows for the integration of conservation objectives and human activities.

Figure 3. Standard Conceptual Layout of an Ideal Biosphere Reserve
(Source: Noss & Cooperrider, 1994:143)

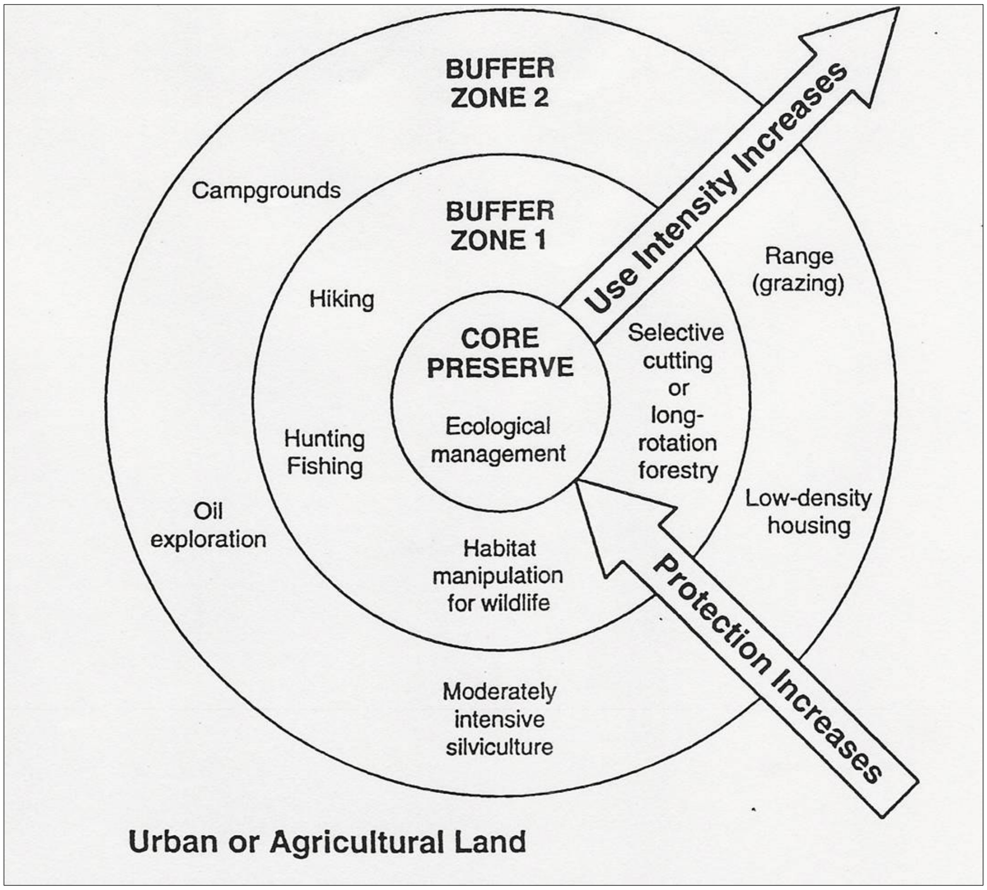


The landscape ecology approach to resource management demonstrates that conservation and development are not mutually exclusive. There is still a critical need to protect core areas and for more and larger conservation areas. However, more ecologically sensitive management of other lands (buffers, urban, farmland, etc) can complement core area conservation and improve ecosystem functions (Noss & Cooperrider, 1994:130). This requires a comprehensive and integrated approach to conservation and land-use planning.

Harris (1984) introduced the concept of the multiple-use model (MUM), which was a generalisation of the biosphere model, to a variety of spatial scales and management scenarios (Noss & Cooperrider, 1994:145). **Figure 4** illustrates a modification of the MUM by Noss and Harris (1986) and Noss (1987b) illustrating core and buffer zones allowing integration of conservation and development involving different intensities of human activities and sensitive land management.

A landscape ecology approach to biodiversity planning also embraces the need for 'representation' (Noss & Cooperrider, 1994:104-105) in which any ecological network seeks to include every possible indigenous species and recognise the inclusiveness of ecosystems. Representation, therefore, also requires a significant amount of protected habitat (Margules, Nicholls, & Pressey, 1988).

Figure 4. A Multiple-Use Model (MUM). An inviolate core reserve surrounded by a gradation of buffer zones, with intensity of human use increasing outward and intensity of protection increasing inward (Source: Noss & Cooperrider, 1994:146)



2.2.3 ECOLOGICAL NETWORKS

Noss (1983), Harris (1984) and Noss and Harris (1986) among others, promoted the reserve network concept – the next level further than isolated biosphere reserves. They took a landscape or regional perspective towards conservation opportunities and recognised the need for animals to move between areas of complimentary habitat.

> *"If functionally connected, a system of reserves may be united into a whole that is greater than the sum of its parts. Although no single reserve may be able to support a long-term viable population of a species with large area requirements... reserves linked by corridors or other avenues of movement may do so."* (Noss & Cooperrider, 1994:144)

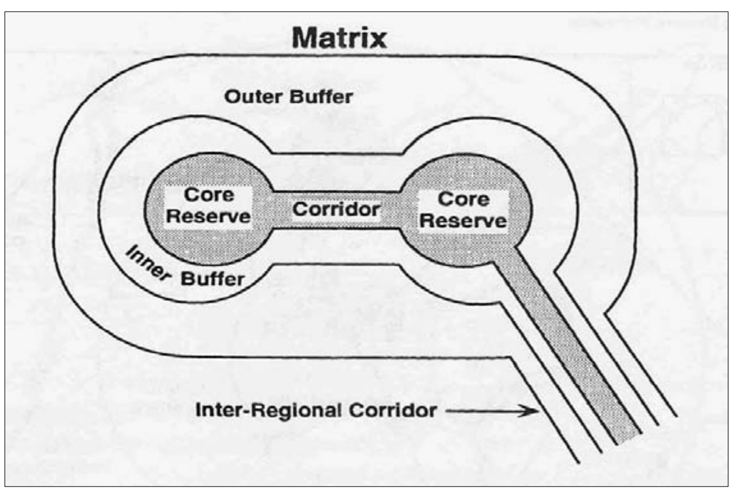
The principle behind this step was that while individual patches, great or small, may not cover the full range of habitat of native species, a well-connected network of such reserves might.

Studies have shown that many animals use corridors when moving through developed (mostly agricultural) landscapes (Wegner & Merriam, 1979), that corridors can improve the persistence of populations (Fahrig & Merriam, 1985; Henderson et al., 1985), and suggested that a network of patches or woodlots may promote persistence of many species in such landscapes (Noss & Cooperrider, 1994:144). Noss (1983) describes a *"regional landscape approach to maintain diversity"* and later Noss and Cooperrider (1994:144) argued for a new approach including:

- Expansion of conservation concerns beyond local sites
- Emphasis on the protection of old growth and other natural areas
- Complex of large and small reserves
- Broad corridors of natural habitat connecting these reserves
- Assessment of design and management options done regionally rather than site by site.

An essential aspect of MUMs (See **Figure 4** in previous section 2.2.1) is that they are located to include biodiversity nodes and be linked by habitat corridors into a functional regional network. In simplified form, the regional reserve network model consists of two or more reserves connected by broad corridors, surrounded by a gradation of buffer zones, and connected to other regions by interregional corridors as illustrated in **Figure 5**.

Figure 5. A Model Regional Ecological Network. Consisting of core reserves, connecting corridors or linkages, and multiple-use buffer zone. (Source: Noss & Cooperrider, 1994:148)



This strategy involves a combination of:

1. More reserves
2. Bigger reserves
3. Interconnected reserves
4. More sensitive management of multiple-use lands.

Noss and Harris (1986) suggest that a connected system of reserves might be greater than the sum of its parts.

Core, ecolinks, buffer and background matrix are the four broad elements of any landscape ecological approach to biodiversity conservation planning and summarised by **Table 6**. Together these four landscape elements provide the major landscape-scale units that can combine to form ecological networks that promote defragmentation of broken landscapes and restore functional ecosystems while providing for human activities.

Table 6. Four Essential Elements of a Regional Ecological Network

Component	Features & Functions
1. Core areas	• Maintained as close as possible to their natural state • Considered the backbone of a regional ecological network • Without strictly protected areas representing most of a region's biodiversity, biodiversity loses are considered unavoidable
2. Multiple-use buffer zones	• Core areas are not sufficient alone to maintain biodiversity. Multiple-use buffer zones compliment core areas • Provides for a greater range of human use than core areas, but still managed with indigenous biodiversity as a priority. Less intense use than in the general landscape matrix serves to shield core areas from harmful activities • May take on the function of core area if disturbance temporarily, or otherwise, make core habitats unsuitable. • Provide potential connectivity between core areas, allowing species to move long distances without interference from human activity and roads
3. Ecolinkages	• Fundamental to the concept of regional ecological networks • Reconnect fragmented ecological landscapes and provide additional habitat
4. Matrix	• Modified or developed areas of urban, farm or cultivated land that can be managed in an ecologically sensitive way and contribute to eco-restoration and biodiversity conservation

(**Source**: A. F. Bennett, 2003; Forman & Godron, 1986; Noss & Cooperrider, 1994:147-156)

Forman (1991:81) suggests three broad strategic advantages of ecological networks:

- They give integrity to existing random patchwork of ecosystems and land uses in the landscape.
- They give integrity to the often random patchwork of laws, regulations, practices, agencies and jurisdictions affecting land.
- They provide a clear objective that landowners, decision-makers and diverse scholars can readily understand and communicate.

Ecological networks not only ensure more ecologically functional landscapes, they can also build resiliency into those ecosystems, habitats and the species that live within them. Individual patches, great or small, may not cover the full range of habitat, but a well-connected network of such patches might.

Margules and Pressey (2000) recognised the need to manage whole landscapes and introduced the concept of ‘systematic conservation planning’, a more systematic approach to locating and designing reserves that builds on the evolving work in conservation biology and landscape ecology.

2.2.4 ECOLOGICAL NETWORKS – A GLOBAL PERSPECTIVE

Ecological networks are a coherent system of natural and/or semi-natural landscape elements configured and managed with the objective of restoring ecological functions as a means the conserve biodiversity while also providing appropriate opportunities for the sustainable use of natural resources. (G. Bennett & Wit, 2001:5). Networks can be implemented at many scales, from regions to countries, and even continents.

There are many different names used to describe this broad approach, the most common being ecological networks, reserve networks, bioregional planning, and ecoregion-based conservation (G. Bennett & Wit, 2001:5). Forman (Pers.comm. 2006) also adds ‘landscape ecology’ to those names. All models are characterized by five key elements (after G. Bennett & Wit, 2001:5):

- **Functional scale** - a focus on biodiversity conservation at the ecosystem, landscape or regional scale
- **Connectivity** - an emphasis on maintaining or increasing ecological coherence, primarily through providing for ecological connectivity

- **Buffers** - ensuring critical areas are buffered from the effects of potentially damaging external activities or influences
- **Restoration** - where appropriate, restoring degraded ecosystems
- **Human activity** - promoting ‘complementarity’ between land uses and biodiversity conservation objectives, and particularly by exploiting the biodiversity value of associated remnant and semi-natural landscapes.

Bridgewater *et.al.,* (1995:67), promoted the critical need for a move towards a bioregional approach to biodiversity conservation through effective, long-term land management that will conserve ecological processes. However, he believed this would require a “paradigm shift” away from traditional methods of planning, conservation and valuing.

Bennett and Wit (2001) reviewed the global use of ecological networks for the IUCN and identified over 150 ecological network initiatives covering a spectrum of international, national and sub-national systems. **Table 7** illustrates this global spread of ecological networks and indicates most popular use in Europe and North America. **Appendix D** identifies a list of specific ecological network projects.

Table 7. The Distribution of Known Ecological Networks

Continent	Number of networks	Percentage of Total
International	10	9%
Europe	42	35%
North America	29	25%
South America	16	13%
Asia	12	10%
Africa	5	4%
Australia	5	4%
Total	119	100%

(**Source**: G. Bennett & Wit, 2001:19)

Bennett and Wit (2001:6) made three key conclusions from their global review of ecological networks:

1. **Increasing global application**: That a generic network model is being increasingly applied to biodiversity conservation, and being applied in a wide variety of environmental and socio-economic circumstances, at different scales and by both government and NGOs.
2. **Sustainability focus**: All networks have double focus on conserving biodiversity and accommodating some degree of exploitation of natural resources – reconciliation of sustainable use of natural resources with biodiversity conservation.

3. **Compatibility**: The success of ecological networks in securing the desired degree of compatibility between natural resource exploitation and biodiversity conservation has not been demonstrated yet.

Bennett and Wit go on to observe,

> *"…the fact that so many ecological network initiatives are now underway, and that this number is rapidly increasing, suggests that the initiators are fully confident that the benefits that this approach promises can ultimately be delivered."* (G. Bennett & Wit, 2001:7)

They offer an interesting suggesting about amalgamating projects:

> *"Since the majority of network initiatives are being developed independently of each other, there could well be substantial value in creating interconnectivity between proximate networks and thereby developing larger-scale constellations of networks."* (G. Bennett & Wit, 2001:7)

More recently, Andrew Bennett (2003) surveyed corridor/ecological network projects, also for the IUCN, as part of a review of corridors and connectivity in wildlife conservation. His numerous case studies produced another set of current or planned ecolink projects that he groups into five categories shown in **Table 8**.

Table 8. Categories of Ecological Network Initiatives

Category	Project
1. Between reserves or large natural areas	• Central Highlands, Victoria, Australia • Eastern Usambara Mountains, Tanzania • Pinhook Swamp corridor, Florida, USA • Mahaweli area, Sri Lanka
2. Linked systems at regional scale	• The Netherlands National Ecological Network • Greenways network for Maryland, USA • National Corridors of Green project, Australia • 'Territorial system of ecological stability' (TSES), Czech Republic
3. Forest conservation and management	• Temperate rainforest corridors, North Westland NZ • East Gippsland, Victoria, Australia • Open 'rides' in UK forests
4. Conservation of large mammals	• Kibale Forest Game Corridor, Uganda • Corridors and buffers. Lake Manyara National Park, Tanzania • Giant Panda conservation, China • Networks for Elephants in India
5. Local networks	• Hedgerow networks, France • Roadside vegetation, southern Australia

(**Source**: A. F. Bennett, 2003:177-204)

Both tables (**Tables 7 and 8**) demonstrate the widespread application of principles of landscape ecology and the use of ecological networks as a strategic conservation planning tool.

Figure 6. North America - An Example of a Proposed Continental-Scale Network. North and Central America conceptual conservation lands to provide continental-scale corridors of the Wildlands Project. Note the insert showing anticipated movement pathways. (**Source**: www.wildlands.org.)

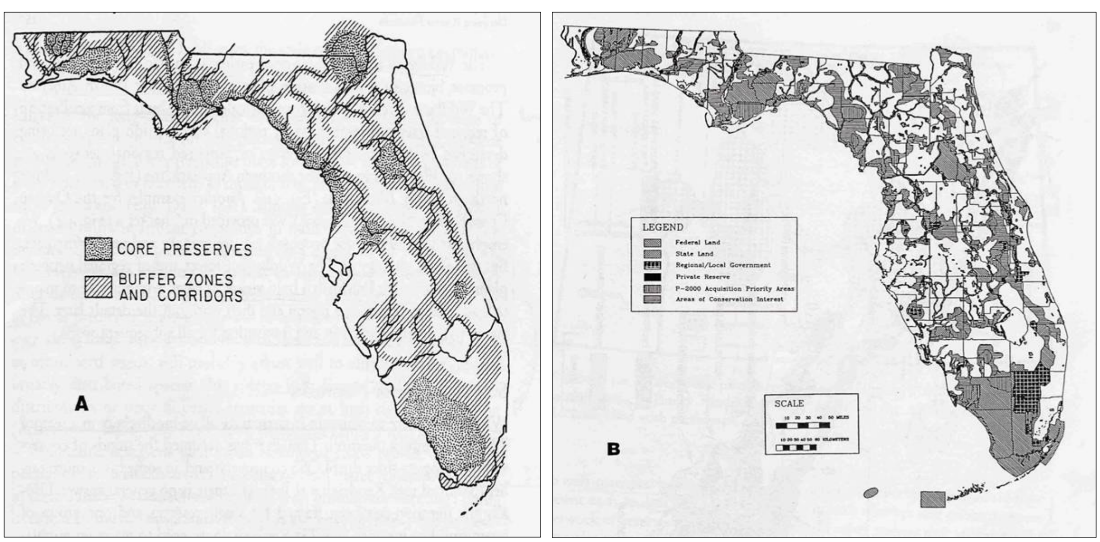
One well-known example where regional communities are involved in such a regional plan development is the continental-scale Wildlands Project in North America, illustrated in **Figure 6**.

The wilderness recovery strategy advocated by the Wildlands Project is a continent-wide, interconnected system of ‘core reserves’ surrounded by ‘buffer zones’ and linked together to maintain functional connectivity of populations and ecological processes (A. F. Bennett, 2003:164).

The extent of the area recommended for inclusion in the recovery network is enormous. It is suggested, for example, that 50% of the land area of USA should eventually be incorporated in core reserves and inner zones of linkage. The estimates of the size of this reserve network. are based on the area required to sustain viable populations of large carnivores such as Grizzly Bear, Gray Wolf, Wolverine and Cougar – species with the greatest area requirements for conservation. At present, the Wildlands Project is largely a vision rather than a firm strategy. It is intended that regional strategies will be developed by local groups as part of a ‘bottom up’ approach, and gradually amalgamated into a continental strategy (A. F. Bennett, 2003:164).This is perhaps one of the most ambitious continental ecological network projects, but demonstrates the potential and capacity of establishing functioning ecological networks.

Another example of large-scale interregional networks is that proposed that for the State of Florida and illustrated in **Figure 7**. This project is intended as one of the regional networks that will form part of the larger continental Wildlands Project described above.

Figure 7. Proposed Regional Reserve Network for Florida. (**A**) Designed to capture hotspots of endemism and large areas with low road density, and provide for movements of wide-ranging species such as Florida panther and black bear. (**B**) Ecological resource areas showing existing public lands, private reserves, proposed acquisitions, and other areas of conservation interest (**Source**: Florida Natural Areas Inventory & reproduced in Noss & Cooperrider, 1994:159).



2.2.5 NETWORK MANAGEMENT CONSIDERATIONS

Establishing an improved reserves network is an essential step towards maintaining biodiversity within a region, but not sufficient. They must then be managed. Protection calls for human intervention, where necessary, to protect from harm, to restore damaged habitat and recover/ reintroduce populations. Noss & Cooperrider (1994:174-177) detail a number of management considerations, but provide a summary of management guidelines based on management guidelines fro the Oregon Coast Range and summarised in **Table 9**.

Table 9. Protection, Management, and Restoration Guidelines for Three Categories of Land

Reserves	Multiple-Use Buffer Zones	Undesignated Lands
No Logging	No logging of original native forest. Selective logging of second growth on long rotation. Restoration forestry	Sustainable resource production
No new roads	No new roads	Protect riparian zones & other sensitive sites
Closure of non-essential existing roads & revegetation. Reduce overall road density to 0.5km/km2	Gradual reduction of non-essential road density to 1.0km/km2	
Limited walking track system		
Private land purchase or management agreements	Conservation easement & management agreements with private landowners	
No stock grazing or horses		
No mineral exploration or mining		
No plant collection for commercial purposes		
Eliminate exotic plants where feasible	Eliminate exotic plants where feasible	
No control of native species		
Only appropriate fire suppression		
Reintroduction of missing species		
No off-road or motorised vehicles	No motorised off-road vehicles on public lands	
Hunting only to control pest species. Legal hunting where appropriate		
Tramping, study, non-manipulative research, education		

(**Source**: Noss & Cooperrider, 1994:175-176)

Such management regimes were controversial in the United States, but could still provide a useful template for transferring landscape ecology principles into land-use planning guidelines and implementation policy.

2.2.6 LANDSCAPE ECOLOGY AND LAND-USE PLANNING

Bennett *et.al.* (2006:675-676) identify that rapid growth in landscape ecology has been based on the premise that conceptual advances in the ways spatial patterns of landscape elements affect ecological processes will provide insights for improved land management. Bennett (2003:43) defines landscape ecology as an…

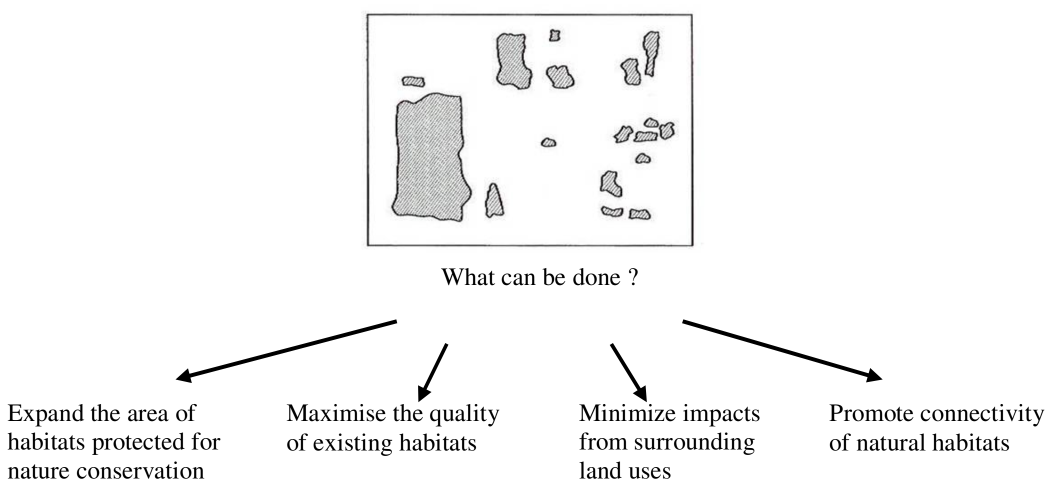
> *"emerging discipline that seeks to develop an integrated, holistic understanding of environments at the scale of whole landscapes. It recognises that all landscapes, those largely in natural form as well as those heavily modified by humans, are mosaics of different types of habitats."*(A. F. Bennett, 2003:43)

From a land-use planning view point, Slocombe (1995:54) believed that the more one applies 'lessons learned' to planning and management, the more one is pushed toward a focus on entire, functioning ecosystems rather than arbitrarily limited protected areas:.

> "[The] *lessons of landscape ecology provide view of protected area as an island from the outside looking in and deals with the island as a remnant of a once larger landscape element, now isolated in an otherwise modified landscape. It identifies the dominant landscape elements, or matrix, and identifies other islands and corridors and network features that may link islands into functionally larger systems."* (Slocombe, 1995:55).

Recognising the critical influence fragmentation has had on once connected landscapes, Bennett (2003:154-156) summarises four approaches that can be incorporated into land-use planning and land management to counter the affects of habitat fragmentation **(Diagram 4).**

Diagram 4. Defragmentation Tools. Four types of measures to counter the effects of habitat fragmentation.



(**Source**: A. F. Bennett, 2003:154)

Bennett provides some options for implementing these strategies and summarised in **Table 10.**

Table 10. Options for Countering Habitat Fragmentation

Tool	Comment	Method Options
Expand the area of protected habitat	• a fundamental and essential basis for nature conservation • large tracts of habitat are more likely to support self-sustaining populations of plants and animals. • increased habitat size also enhances capacity for greater species richness, support entire communities, and maintain ecological processes	• including additional areas in nature reserves or overall system • statutory provisions or community programmes to protect natural areas • statutory provisions or community programs to minimise further clearing and fragmentation • deliberate regeneration or revegetation programmes in adjacent lands • regeneration or revegetation in-kind where clearing happens
Maximise the quality of existing habitats	• the value of habitat is increased when managed to enhance essential ecological resources	• minimising and controlling land uses that degrade the natural environment and reduce its sustainability • managing harvesting of natural resources (e.g. timber, wildlife) to ensure long-term sustainability & minimise adverse impacts on habitats • maintain natural disturbance regimes that promote vegetation succession and temporally vary habitats and resources
Minimize the impacts from surrounding land uses	• Processes outside fragments are a major influence on populations and communities within fragments • These effects can be countered by a range of actions	• zoning of land uses & the control of certain land uses close to important natural areas • the use of buffer zones around conservation areas to minimize the impact of external influences • management programmes to control the number & impacts of pest species
Promote connectivity of natural habitats to counter the effects of isolation	Directly counter detrimental effects of isolation through assisting • movement • dispersal • continuity and ecological processes	

(**Source**: A. F. Bennett, 2003:154-157)

These four tools can be done at a range of scales – from the development of conservation plans for individual properties, to the planning and implementation of regional and national conservation strategies (A. F. Bennett, 2003:54). They also set the context in which connectivity has a role in conservation of flora and fauna in fragmented landscapes. It is one of the measures to secure and enhance nature conservation.

Again, it is quite clear from this that connectivity is not a solitary solution to problems arising from habitat fragmentation (A. F. Bennett, 2003:156; A. F. Bennett et al., 2006:680-682). All four methods are part of a broad 'tool box' necessary for the retention and expansion of protected natural habitats. Any strategy based solely on developing linkages will be deficient and unsuccessful (A. F. Bennett, 2003:156). Current evidence suggests, at least in the short term, the total amount of habitat is often a more significant determinant of the status and persistence of species in modified landscapes than spatial pattern or configuration of habitats (A. F. Bennett et al., 2006:682 citing Trzcinski et.al. 1999 & Fahrig 2003).

Andrew Bennett makes the following significant point about the role of connectivity:

> *"Promoting landscape connectivity does… have a distinctive role; it allows a fundamentally different approach to nature conservation in developed landscapes. The first three measures… are each based on improving the conservation potential of* individual *areas of habitat. However, where there is effective connectivity, there is the opportunity to achieve conservation goals through* linked systems of habitat*."*
>
> *"The distinctive role of connectivity in a conservation strategy is to 'tie together' habitats into a linked system to restore the natural flow and interchange of animals and plants across the landscape"* (A. F. Bennett, 2003:156. Author's emphasis)

2.2.7 THE CURRENT STATUS OF LANDSCAPE ECOLOGY - INTERVIEWS

Given that landscape ecology is an emerging discipline in which ideas are developing quickly, I undertook interviews with leading practitioners of landscape ecology to obtain updates on their views about the international status of landscape ecology. **Appendix B** lists the interviewees, the broad questions asked of interviewees, and provides a detailed summary of the interviews. These interviews offered numbers of important comments on the status of landscape ecology and its application that are covered in this section.

On the 'corridor debate', Noss (Pers.comm. 2006) believes,

> "[The corridor] *debate has 'fizzled down'. Virtually everyone agrees now, that connectivity is an important consideration much of the time in reserve design and landscape management, and that corridors are often the best way to achieve connectivity. Much of the interest now is on the issue of how to design corridors (or alternately, a suitable landscape matrix)"*.

This is a sentiment shared by Simberloff (Pers.comm. 2006) who says,

> *"The* [corridor] *debate is more on how much and where, and how to determine these things... almost everyone feels that in most situations, connectivity at some level is important, but how to achieve it (corridors, matrix management, moving individuals around, etc.,) is very much up in the air, and very system specific."*

Forman (Pers.comm. 2006) comments that,

> "*While a few' nay-sayers' remain, overall ecologists and planners note that the major benefits of natural corridors overwhelm any minor shortcomings."*

He makes the further point that some of the most important landscape types are dominated by corridors (Forman, 1991:71). From a biodiversity conservation perspective, it is very hard to dismiss corridors as a significant tool in accomplishing sustainable and effective ecological outcomes.

On landscape ecology generally, Forman (Pers.comm. 2006) observes that the first 20 years' development of landscape ecology is widely used and spreading into more disciplines including ecology, forestry, conservation biology and landscape architecture. Its use is still growing in transport and urban planning, but as yet, not too much in agricultural planning yet. Its greatest use at the moment is in underpinning planning and management in addition to its own science. Andrew Bennett (Pers.comm. 2006) considers landscape ecology is the cutting edge of conservation biology and biodiversity planning, and that Richard Forman's work (Forman, 1995; Forman & Godron, 1986; Forman et al., 2003) are still the best texts on the subject.

Forman (Pers.comm. 2006) believes landscape ecology has at least two key strengths. Firstly, that it provides a set of principles that can be used over large areas or whole landscapes that we did not have prior to the early 1980s, and instead looked at localised habitats and analysed them in isolation as if regions are homogeneous, which they are not. Secondly, that it can accommodate and integrate multi-sectoral interests and the interests of a wide variety of disciplines, which it treats as all being important. A critical weakness, however, is a lack dialogue with the traditional anthropocentric social sciences and socio-economic disciplines, and difficulty in finding a compatibility with landscape ecology that is strongly oriented towards natural systems. He believes there needs to be synergies where planning can occur in an intelligent way for the likes of transportation, economic development, housing, and employment as well as water supply, biodiversity, recreation. These are views shared by

Saunders (Pers.comm. 2006) who believes that the most significant barriers to addressing reconnecting the indigenous landscape and taking a strategic comprehensive approach to conservation/bioregional planning are in fact sociological and political, rather than ecological. Andrew Bennett (Pers.comm. 2006) considers one of the keys to achieving better biodiversity outcomes is translating the science of landscape ecology into the community and action. He believes that top-down and bottom-up conservation involvement are both required. He further believes that the entry point for this translation is linking into human need though a focus on the environmental services provided by nature reserves and remnants. He believes these services should be used as a means of promotion, maintenance or protection of biodiversity and habitat.

Despite this, Forman has experienced very little resistance to the application of landscape ecology principles from traditional planning. He believes this is because it has insufficient profile to create a 'threat' and therefore any dialogue. Commenting on this further, he says, that because landscape ecology is so spatially oriented, politicians, planners, managers and other decision-makers like it. *"It's a map and everyone is able to speak the same language. There is no hocus pocus in it. You don't have to have faith in it, you just have to understand it."* Another reason he believes he has not experienced resistance to landscape ecology is that he is generally dealing with thinkers and planners who want to solve problems. Such people are open to new ideas, and landscape ecology is such a strong meshing of science and spatial patterns - which are universal ideas - that it provides a 'handle' that people and decision-makers can get hold of.

> *"For a planner or policy maker it has to be simple enough to understand it, be able to explain it, and to be able to defend it against a hostile audience. It deals with situations such as species versus development, but puts it in a framework that is not 'us and them' and avoids a conflict situation from the beginning… The metaphor of a spatial arrangement is a handle for decision-makers to make wise decisions. Using a spatial plan, you can simply change the pattern and if you think about the pattern in advance you can make a better spatial pattern or mitigate the ones that are there."* (Recorded pers.comm. Forman 2006)

Forman cited many positive examples where the principles of landscape ecology are currently being applied or becoming increasingly popular. These include:

- The Greater Barcelona Project. The mayor and planners wanted to stop the 'wasting of land', unnecessary urban sprawl and the loss of strategic natural resources. Instead, they wanted a bigger and longer-term picture to guide strategic protection and development and secure the economic future of the region.

- The western wheatbelt of Western Australia. An agrarian landscape where wheat production and woodland revegetation are successfully occurring based on remnant woodlands and roadside planting in partnership with landcare groups.
- The Netherlands Ecological Network. A government commitment to increase sparse woodland remnants by at least 10% is being met by establishment of large patches around existing small patches.
- The USA Forest Service work in Minnesota/Wisconsin/Michigan where a whole landscape view considers the effect of forest cutting for not just forest products but also water, soil erosion, fish, wildlife, recreation and road construction and indirectly for the economics.
- The Pacific Northwest where traditional dispersed-patch cutting was abandoned in favour of more environmentally-friendly methods.
- One of the growth areas in landscape ecology is addressing the impacts of roading networks, which traditionally fragments the landscape and affect water, erosion and sedimentation. Forman's book *Roading Ecology* (Forman et al., 2003), has been selling well in USA and overseas as the first book dealing with roading networks and their impacts.

2.2.8 CONCLUSIONS - MOVING BEYOND RESERVES

Poiani & Richter (1999) describe landscape ecology as a paradigm shift, or "new vision", in conservation planning representing as it does a shift from conservation based on rarity to one based on ecosystem- and landscape- level concepts and a greater emphasis on conserving ecological processes and functional landscapes to, *"dramatically improve… efficiency and effectiveness"* of conservation outcomes. A fundamental understanding in landscape ecology is that by saving the ecosystem, you save the species and habitats within that ecosystem.

The traditional approach to nature conservation, as discussed at the beginning of this section, has been based on selecting and maintaining areas as reserves of one form or another – often with little reference to ecological systems. These are usually national parks or similar reserve categories (on public or private land) in which biodiversity conservation is given high priority; or, in some cases, other types of reserves in which conservation goals are balanced with other forms of land use. The typical pattern of reserves is of a set of parcels of land, scattered across a region or country, and representing a range of different ecosystem types. The growing view of conservation biologists and landscape ecologists is that a ‘reserve-based approach’, by itself, is not adequate to ensure long-term biodiversity conservation of native flora and fauna on its own (A. F. Bennett, 2003:157). Increasing the number and extent of reserves is important, but even this will be insufficient in many regions.

Andrew Bennett (2003:159-163) summarises the main limitations of a reserve-based approach to conservation:

- **Reserves are not representative**. They rarely represent all or even a balanced representation of all natural communities within a region or country. This limited or lack of representation means that many plant and animal species occur mainly or wholly outside reserves.
- **Most reserves are too small** to sustain viable populations and natural ecological processes. For reserves to conserve entire faunal assemblages, they must be of sufficient size to allow natural disturbance regimes (e.g., fire, flood, windthrow) to continue without eliminating species and provide the full range of habitat and food sources for species to live.
- **Species ignore boundaries:** Daily, seasonal and geographic movement patterns of animals regularly cross boundaries. If resource are lost that species use outside of reserves the effectiveness of a reserve is reduced.
- **Reserves are not isolated from surrounding land uses:** Reserves do not sit in an ecologically neutral matrix (c.f., island biogeographic theory). Instead, they are subject to a range of pressures from surrounding environments. Reserve management, however, generally does stop at the reserve boundary and reserve managers rarely have authority to influence land uses and practices on adjacent land and counteract those influences

Reserves are still an essential component of any integrated landscape approach. Now, however, there is widespread recognition that in many regions it is necessary to extend the reserve-based approach to management of biodiversity conservation in the whole landscape, not just within reserve boundaries – to integrate conservation with surrounding land uses (A. F. Bennett, 2003:157, 163, 167).

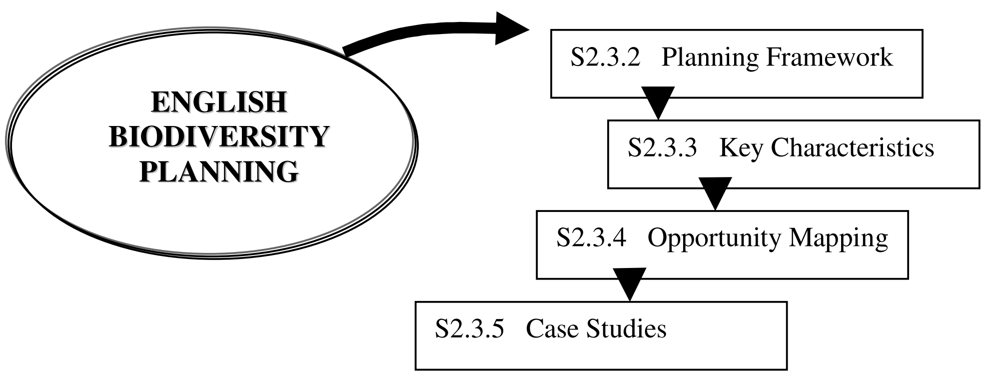
2.3 ENGLISH PLANNING MODEL OF BIODIVERSITY CONSERVATON

2.3.1 INTRODUCTION

The English planning provisions for biodiversity conservation provide a useful model for translating a landscape ecology approach into a sustainable spatial planning framework. This model demonstrates a statutory commitment to comprehensive and effective implementation of biodiversity conservation at all levels of government, sectoral interests and communities. It is a combination of 'top-down, bottom-up' planning that recognises and protects existing biodiversity – species and habitat – and also actively promotes and enables the enhancement and re-creation of habitat wherever possible through a new tool - 'opportunity mapping' - and appropriate development controls. It also actively attempts to address the potential impact on biodiversity of predicted global warming and safeguard species and habitats against expected relatively rapid climate and habitat changes.

Diagram 5 shows the structure and content for this section on the English biodiversity planning.

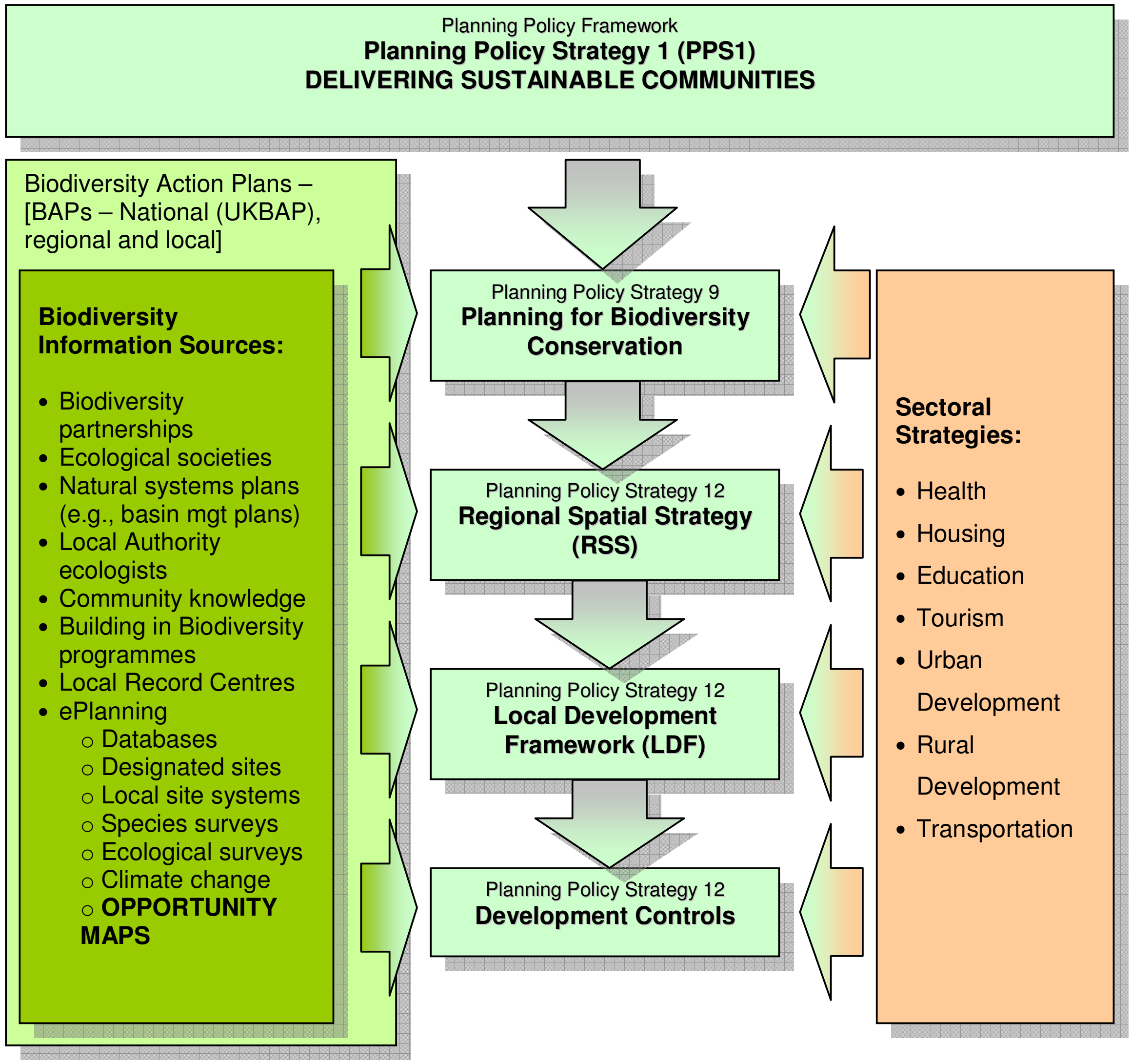
Diagram 5. Structure of Section on English Biodiversity Planning



2.3.2 PLANNING FRAMEWORK

Key to achieving this biodiversity conservation is the development of a high level of spatial and technical information on biodiversity resources and guidelines for its protection, leadership and strategic partnerships at the national, regional and local levels. **Diagram 6** summarises the key elements of the policy framework for biodiversity conservation planning.

Diagram 6. Planning Framework for Biodiversity Conservation in England



2.3.3 KEY CHARACTERISTICS

This framework demonstrates a number of important characteristics that could provide an instructive model for the New Zealand context:

1. **Sustainability -** Biodiversity planning complements an overarching strategic national 'sustainability' policy (*Planning Policy Strategy (PPS) 1 – "Delivering Sustainable Communities*" (ODPM, 2005c)) in which environmental sustainability is integrated with economic and social issues.

2. **Leadership –** Conservation leadership occurs at all levels of government and follows a hierarchy of national policies and guidelines. A set of Planning Policy Strategy (PPS) have been developed for a range of planning issues (See **Appendix E** for a full list of documents and policy statements affecting or affected by biodiversity conservation). Planning Policy Strategy 9 - *Biodiversity and Geological Conservation* (ODPM, 2005d) - sets out the specific national policy relating to achieving sustainability of biodiversity resources. It follows the Government's vision for conserving and enhancing biological diversity in England, together with a programme of works to achieve it set out in the Biodiversity Strategy for England (Defra, 2002). An extensive guideline - *Planning for Biodiversity and Geological Conservation: A Guide to Good Practice* (ODPM et al., 2006) – expands on the guiding principles and provides official advice on best practice biodiversity conservation consistent with PPS1 and PPS9 directives for each level of planning. It includes extensive case studies, all referenced to relevant websites. It also contains a wealth of other relevant documents and policy statements expanding directions and guidance on the proper implementation of the planning framework and quality control to ensure the intended beneficial biodiversity.

   In moving towards this vision, the Government's stated objectives for planning are:

   - ***to promote sustainable development*** *by ensuring biological… diversity are conserved and enhanced as an integral part of social, environmental and economic development, so that policies and decisions about the development and use of land integrate biodiversity... with other considerations.*

   - ***to conserve, enhance and restore the diversity of England's wildlife****… by sustaining, and where possible improving, the quality and extent of natural habitat…; the natural physical processes on which they depend; and the populations of naturally occurring species they support.*

   - ***to contribute to rural renewal and urban renaissance by:***

     - *enhancing biodiversity in green spaces among developments so that they are used by wildlife and valued by people, recognising that healthy functional ecosystems can contribute to a better quality of life and to people's sense of well-being; and*

     - *ensuring that developments take account of the role and value of biodiversity in supporting economic diversification and contributing to a high quality environment.*(ODPM, 2005d:2)

PPS 9 sets out the key principles that regional planning bodies and local planning authorities should adhere to for ensuring potential impacts of planning decisions on biodiversity conservation are fully considered. **Table 11** summarises the guiding policy principles.

Table 11. Policy Principles Guiding Biodiversity Protection in England

Principle	Policy Statement
CURRENT INFORMATION	"Policies and planning decisions should be based on up-to-date environmental and biodiversity information."
PROTECTION	"Policies and planning decisions should aim to maintain, and enhance, restore or add to biodiversity conservation."
STRATEGIC	"Policies should take a strategic approach to the conservation, enhancement and restoration of biodiversity ad recognise the contribution of sites, areas and features both individually and collectively."
DESIGN OPPORTUNITIES	"Policies should promote beneficial biodiversity conservation opportunities within development designs."
PERMITTED ACTIVITY	"Treat as a permitted activity developments whose primary objective is biodiversity conservation or enhancement."
PREVENTION	"The aim of planning decisions should be to prevent harm to biodiversity conservation interests."

(**Source**: ODPM, 2005d:3)

Notable points from these principles include:

- Emphasis on using the most recent information,
- Opportunity should be taken for enhancing or even creating biodiversity, not simply maintaining it,
- Design of development should include consideration of opportunities beneficial to biodiversity.

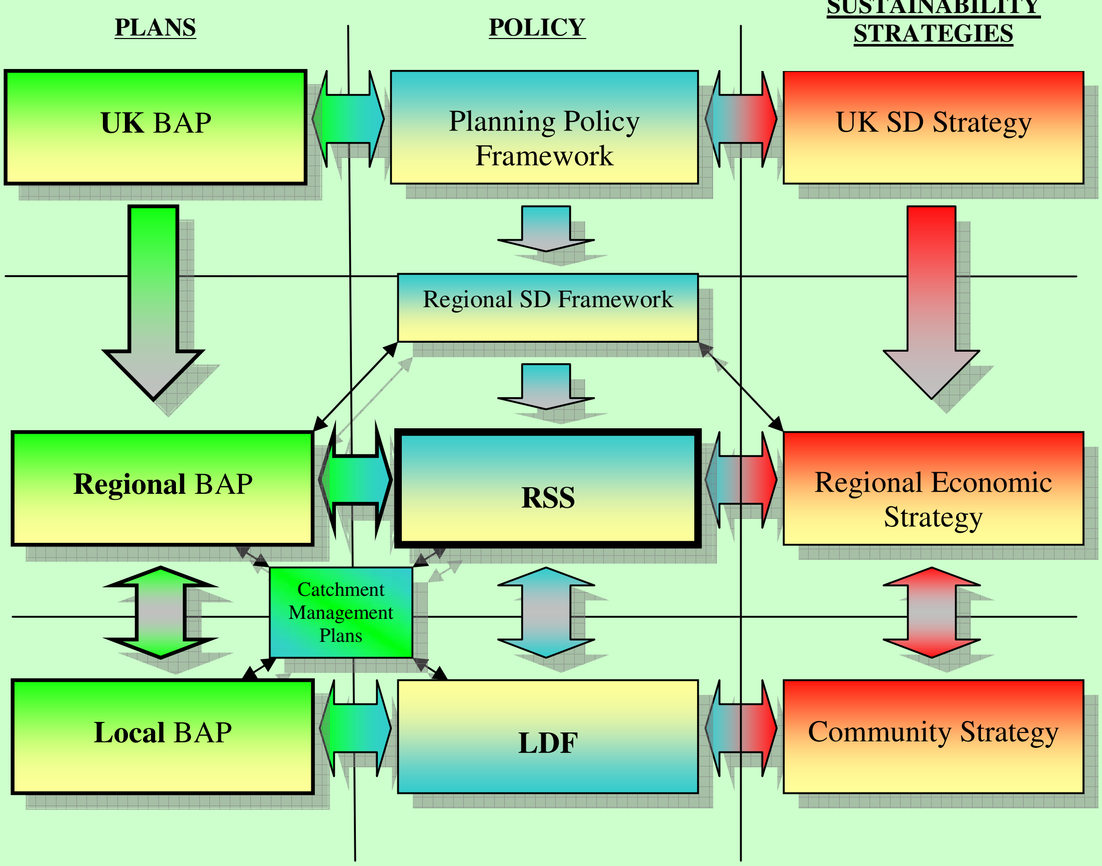
These national policies are linked to and implemented by Regional Spatial Strategies (RSS) and Local Development Frameworks (LDF) where biodiversity conservation is mandatory (ODPM, 2004c, 2004d). Leadership forums are established at the national, regional and local level to plan and oversee biodiversity conservation.

3. **Comprehensive** - Biodiversity conservation covers public and private land, rural and urban, terrestrial, freshwater and marine environments. Each level and sector of planning has its own set of comprehensive guidelines, including for biodiversity conservation (ODPM et al., 2006) .The guidelines are produced by central government to ensure a consistent approach. Flexibility recognises that there is no 'one-size-fits-all' and provides for local and regional decision-making.

4. **Integrated -** PPS1, RSS & LDFs integrate the policies of all sectors (eg transport, housing, etc) including biodiversity conservation. Integration ensures a consistent, comprehensive and sustainable approach to land-use planning. The critical document and process in integrating biodiversity planning and the plans of other sectors is the Regional Spatial Strategy (RSS). **Diagram 7** illustrates the RSS development process and its relationship with key biodiversity and other strategic documents.

The overarching statutory purpose of RSS is to contribute towards achievement of sustainable development. Various plans, policies and regional strategies are brought together in forming the RSS. A major input to address biodiversity objectives in the RSS is the regional BAP.

Diagram 7. Development of Regional Spatial Strategy



(**Source**: Countryside Agency, English Heritage, English Nature, & Environment Agency, 2005:8; ODPM, Defra, & English Nature, 2006:25)

The RSS provides a means of working with regional and national partners (e.g. regional biodiversity forums, English Nature, Environment Agency) to identify regional priorities and policies for biodiversity conservation and to provide a framework for implementation. The RSS have an important role in spatial delivery of regional biodiversity strategies, through:

- Providing strategic policies and general principles;
- Influencing LDFs; or by
- Guiding other plans and strategies affecting development and land use.

The success of RSS in biodiversity conservation, is tested by Sustainability Appraisal, Examination and Annual Monitoring Report processes (ODPM et al., 2006:24).

PPS11 requires RSS to provide a broad development strategy for the region for a fifteen to twenty year period that should include taking into account, "*priorities for the environment, such as countryside and biodiversity protection*" (ODPM, 2004c:1). RSS integrate a variety of other regional strategies, for example: that include:

- cultural strategies; and
- forestry strategies*;(ODPM, 2004c:10)*

In this way RSS have a key role in providing a comprehensive, integrated approach to spatial planning that includes biodiversity conservation. Regional planning bodies are required to liaise closely with regional biodiversity fora, English Nature and the Environment Agency to identify:

- Current regional and sub-regional distribution of priority habitats and species
- Internationally and nationally designated areas; and
- Broad areas for habitat restoration and recreation. (ODPM, 2005d:4)

They are also required to address the affects of climate change on the distribution of habitats and species. (ODPM, 2005d:4). Specifically, RSS are required to (ODPM, 2005d:4):

- Incorporate biodiversity objectives;
- Address regional, sub-regional and cross boundary issues in relation to habitats [and] species… through criteria-based policies;

- Include policies to conserve and enhance biodiversity at the regional and sub-regional level;
- Include targets for the restoration and re-creation of priority habitats and the recovery of priority species populations, linked to national goals; and
- Identify suitable indicators for monitoring biodiversity (ODPM, 2005e, 2005f).

PPS12: Local Development Frameworks (ODPM, 2004d) also requires that LDFs take an integrated approach to planning for biodiversity when preparing local development documents whose policies should reflect and be consistent with national, regional and local biodiversity priorities and objectives, including those agreed by local biodiversity partnerships (ODPM, 2005d:4). This includes identifying any areas or sites for the restoration or creation of new priority habitats which contribute to regional targets, and support this restoration or creation through appropriate policies (ODPM, 2005d:4). There are a range of good practice and technical guides to instruct on the development of sustainable LDF's consistent with national and regional objectives (ODPM, 2004b, 2005a, 2005b, 2005f).

Development Controls are addressed in the guide to good practice for PPS9 (ODPM et al., 2006:44-59). The control process is recognised as a critical stage in delivering protection and enhancement of biodiversity required by PPS9. A variety of resources and information are available to support effective control. These sources are listed in **Appendix F.** Significantly, these 'building in biodiversity' initiatives also illustrate the recruitment and integration of sectoral interests to participate actively in biodiversity conservation and more ecologically sensitive and sustainable development.

5. **Biodiversity Action Plans (BAPs)** – Developed at all levels of government to guide and prioritise conservation action. The UKBAP is the over-arching document, sets international and national priorities, and informs regional and local BAPs that contribute to RSS and LDF.

6. **Partnerships** – mandatory semi-formal, multi-sectoral forums or partnerships at national, regional and local levels are a fundamental element in implementing sustainable and effective biodiversity conservation. Forums identify national, regional

and local ecological resources and priorities that then feed into the relevant level of planning policy. Partnerships are recognition of the need for 'localised' information and expertise to inform policy and planning provisions and ensure more sustainable longer-term outcomes. Sectoral interests are encouraged and assisted to produce industry guidelines (e.g., *'Working with Wildlife'* from the construction industry (CIRIA, 2004, 2006).

7. **Inter-agency Approach** – while this may have drawbacks, responsibility for action does not solely rest with one department or agent. All government and autonomous environmental agencies (i.e. ODPM, Defra, English Nature, Countryside Commission, and the Environment Agency) are involved in contributing to and leading appropriate aspects of biodiversity conservation at national, regional and local level.

8. **Information Availability – '**ePlanning' has been comprehensively embraced in England, particularly in assisting biodiversity planning (ODPM, 2004a). E-Planning is a critical strategy to facilitate more community involvement in planning processes and in producing better and more sustainable outcomes through increased participation, public empowerment, improved knowledge exchange and knowledge integration (ODPM, 2004a:4).

   Multiple information sources are available online and available to individuals and public and private agencies (See **Appendix F** for list of sources). This facilitates greater and more informed public involvement in planning processes. It also assists in the collection of further data and facilitates use of the most up-to-date information upon which to base decisions. Sites are available on species, habitat, and climate change (Details of excellent examples of interactive websites – including web addresses - are also listed in **Appendix F**). Provisions are made for establishing Local Record Centre where environmental information is gathered and accessed as a 'one-stop, environmental shop' for public use.

   A 'Good Practice Summary' for 'information and evidence' (ODPM et al., 2006:3) recommends that planning authorities establish and maintain a number of good practices summarised in **Table 12**.

Table 12. Information & Evidence – Good Practice Summary

Web-based	Make full use of GIS & other web-based information sources
Ecological survey	Identify key information gaps & fill these with further surveys
Habitat enhancement	Use information to identify & map areas best suited for proactive enhancement measures
Integrate BAPs	Integrate information & priorities established in biodiversity action plans (BAP) & biodiversity forum partnerships
Local Record Centres (LRC)	Support establishment of Local Record Centres
Ecological expertise	Ensure access to in-house or shared ecological expertise
Local knowledge	Tapping the knowledge & experience of the wider community

(**Source**: ODPM et al., 2006:3)

This good information base is intended to provide planners with an understanding of the natural environment including the landscape and the range of habitats supporting natural processes and human activities. Planners are then enabled to recognise those natural features distinctive to their area, their distribution, extent and trends affecting them and identify natural features most vulnerable to the effects of climate change

9. **Ecosystem or Landscape Ecological Approach** - This approach is accepted 'best practice' and reflects the policy and practice framework used in Europe and set by the EU (Saunders & Parfitt, 2005 & pers.comm. Tricker 2006). Policy ensures cross-boundary issues are appropriately addressed.

10. **Climate Change -** Impacts on biodiversity are accepted and appropriate responses to reduce impacts and facilitate species and habitat adaptation are mandatory in planning for biodiversity conservation. While this thesis will not provide detailed analysis of the biodiversity implications of climate change, none-the-less it is a important component of the English biodiversity planning model and some notes included here for instruction and completeness.

English planning provisions recognises climate change and its likely impact on biodiversity resources and their conservation. An English Nature Research Report (English Nature, 1993:8) on the role of corridors, stepping stones and islands for species conservation in a changing climate summarises the impact and the need to reconnect the ecological landscape:

> *"Climate change may result in a changed geographical distribution of suitable habitats for species of nature conservation interest. In order to survive and reach their potential, such species will need to move to new locations. It is often asserted that species movement will be assisted by the existence of corridors, i.e., by strips of habitat connecting larger habitat patches. An eloquent statement of this view is given by Huntley (1991), who writes: "Reserves must no longer be selected primarily upon the basis of rarity of the organisms currently found within their boundaries; these organisms may in future migrate elsewhere. Instead we must conserve as large an area and as diverse a range of physical habitats as possible, so as to achieve resiliency in our network of reserves. We must also place greater emphasis upon achieving a connected network that will facilitate migratory movements; so called 'wildlife corridors' will assume great importance in the future and must become a required part of any structure plan or development plan".*

Ecological corridors and the concept of defragmenting the English landscape are a critical part of planning for climate change. All levels of English planning, including biodiversity conservation planning, are required to address the likely impacts of climate change (Piper, Wilson, Weston, Thompson, & Glasson, 2006:56).) Central government developed *The Planning Response to Climate Change: Advice on Better Practice* (ODPM, 2004e) to familiarise planners with the issues. It reflects experiential and scientific evidence that climate change is occurring and recognises that this change:

- Will cause change in natural processes
- May make existing fragmented habitat more vulnerable unless space for adaptation is available
- May also reduce the extent of protected areas due to increased flooding and sea level rise (*Op.cit.* p.52).

The best practice guide recommends, *"Planning ahead requires long-term vision to maintain and enhance biodiversity, improve connections and provide capacity for future change"* that involves regional and local planning authorities adopting both short-term protection and 'climate-aware' long-term objectives and policies and identifying and dealing with cross-border issues (*Op.cit.* p.52-54). It specifically recommends that local planning authorities:

- Build local biodiversity targets into planning

- Identify areas for new habitat that may include "safeguarding buffer zones or corridors to allow adaptation… to reverse fragmentation and improve connections between natural habitats in order to provide stepping stones or corridors for migration or dispersal"
- Identify opportunities for biodiversity enhancement
- Use informed landscaping for relevant species with appropriate planting regimes
- Attend to coastal habitats, especially, through Coastal Habitat Management Plans (CHaMPS).

There are a number of useful and still developing information sources for climate change impact. These include UKCIP (UK Climate Impact Programme) to provide advice to clients on likely effects, MONARCH which specifically models predicted biodiversity movements under climate change; and MONARCH that specifically develops and promotes spatial planning mechanisms to assist wildlife adapt to climate change. More detail on these sources of climate change information is provided in **Appendix F**). As a result of this kind of generated information, spatial planning systems have begun to integrate more dynamic conceptions of biodiversity, such as the need for space, green infrastructure, ecological networks and the integration of biodiversity into development (Piper et al., 2006:57).

11. **Biodiversity Mapping.** Under this planning framework, RSS & LDF are required to identify opportunities to not only protect, but also enhance, re-create or create wildlife habitat and develop appropriate planning provisions (ODPM, 2005d:2). This has resulted in the development of what has been called 'opportunity mapping' (Catchpole, 2006; Saunders & Parfitt, 2005) that has particular potential application to the New Zealand context and warrants more detailed description and discussion that is provided in the following section.

2.3.4 OPPORTUNITY MAPPING

Opportunity mapping provides an example of landscape-scale, strategic conservation planning that is absent from the New Zealand biodiversity policy framework and has potential application in the New Zealand context. Saunders & Parfitt (2005) provide a useful definition and summary of opportunity mapping and its significance:

> *"…broad scale visions for change which offer a spatially-base tool for identifying where environmental enhancement could or should be delivered in the future, using existing areas of environmental value as a starting point… Opportunity mapping offers a refreshingly holistic approach to envisioning a future landscape richer in biodiversity* [while]*… taking full account of other environmental interests (including landscape, historic, access, resource protection). It encourages practitioners to recognise and plan for necessary ecological functionality of that landscape, offering a practical tool for managing the effects of climate change on natural systems. It represents a natural spatial extension of the biodiversity action planning process, allowing 'opportunity space' for the achievement of BAP targets to be defined. It enables interdisciplinary working and integration between branches of the heritage (historic and cultural) sectors, and between environmental, social and economic planners. And it offers a product which… can* [potentially] *convey the forward agenda for biodiversity in a fully integrated context to a lay audience more effectively and engagingly than text or figures can do… The message of opportunity maps is that future sustainability of habitats demands not only that existing habitat patches are protected, but that they are expanded and connected across landscapes, and that such expansion will be more feasible and appropriate in some locations than others."* (Saunders & Parfitt, 2005:7&15.)

The ecological theory behind opportunity mapping originates from landscape ecology (Saunders & Parfitt, 2005:15). In the English situation, it is recognised that principles from landscape ecology can be used either loosely or rigidly in opportunity mapping. Maps may be simple and 'basic' or more accurate and definitive. In practice, a full spectrum of approaches are presently being used (Saunders & Parfitt, 2005:15). There are currently over 30 opportunity mapping initiatives throughout England (See map of locations in **Appendix G**) expressing a range of approaches (Saunders & Parfitt, 2005:17) from the highly technical to the more 'basic' envisioning maps aimed at stimulating public understanding, support and participation.

An independent survey of these mapping initiatives recommends a number of simple good practice principles to encourage a consistent and effective approach, while acknowledging a need for flexibility (Saunders & Parfitt, 2005:46). **Table 13** summarises the good practice principles developed from a review of the various opportunity mapping initiatives. This demonstrates parallels with the key characteristics of the English planning framework for biodiversity conservation and that right processes are as important as, and complementary to, effective outcomes.

Table 13. Good Practice Principles for Opportunity Mapping

PROCESS	**Derived from other areas of policy development and applied to map-making. The process is important in order to gain widespread support and 'buy-in' to be effective.**
	• Clarity of purpose • Links from and to the relevant BAP • Based on strong partnerships from the beginning • Partnerships should be on-going to invest long-term in the development of the map and the implementation of the action it proposes • Ensure continuity across boundaries and between scales of mapping • A dialogue with local expertise to give authority to the map • Links to other sectors e.g., historic environment, landscape, resource protection, access.
METHODOLOGY	**Technical learning from mapping experience**
	• Use the best data available, but not necessarily constrained by its absence • Adopt a level of complexity or simplicity consistent with the map's purposes • Use at least a basic ecological rationale • Use a landscape framework to provide for a holistic coverage of the subject area
COMMUNICATION	**Communication of map products themselves**
	• Designed to suit its purpose • Understandable to look at • Avoid misunderstanding through careful wording accompanying the map • Communicate map to intended audience through the right media
	(**Source**: Saunders & Parfitt, 2005:8,16,22-26,46-53)

Appendix H provides further detail on the development and application of opportunity mapping in England.

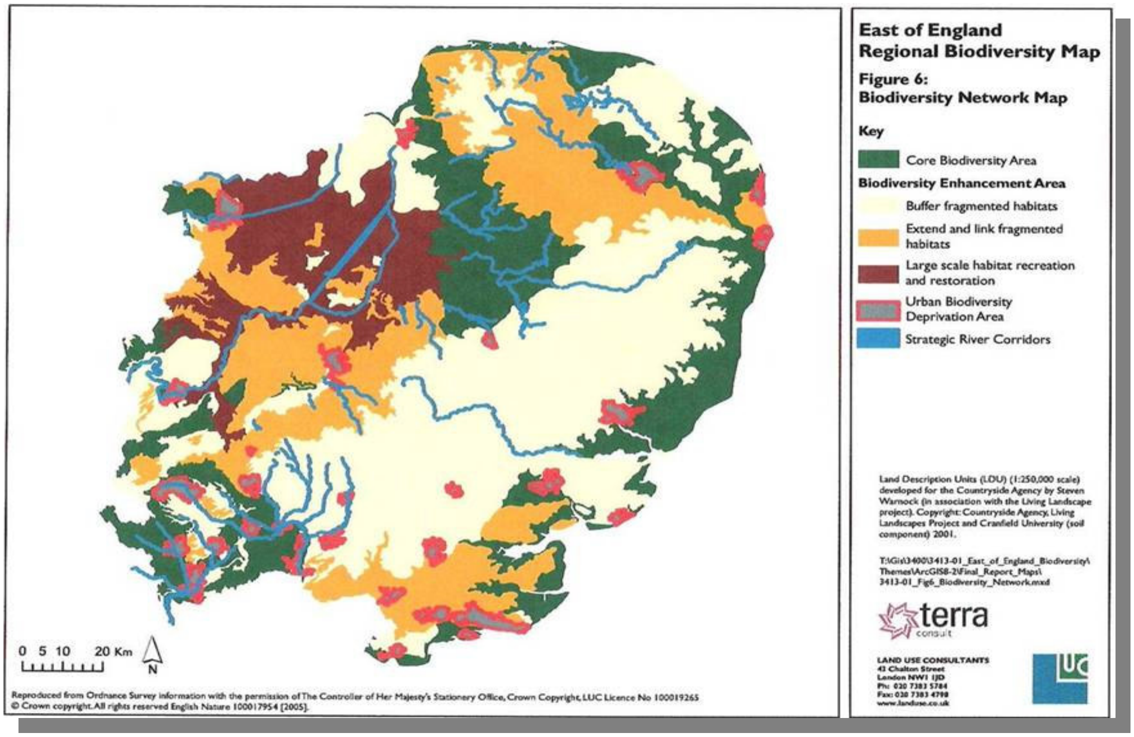
2.3.5 EXAMPLES – CASE STUDIES

Two examples illustrate these good practice principles and different approaches to opportunity mapping (Other examples are also provided in **Appendix H**). These case studies strongly inform the development of the LEEP Model for biodiversity conservation proposed and described in **Chapter 4**.

Case Study 1 – East of England Regional Opportunity Map

The East of England regional opportunity map (**Figure 8**) was developed in response to predicted high regional growth and the identified need for a network of biodiversity areas and corridors to both conserve existing biodiversity and restore and regenerate biodiversity in 'deficit' areas, set against uncertainty of climate change (ODPM *et al.*, 2006:12). The map is a combination of landscape and biodiversity datasets (Saunders & Parfitt, 2005:75-77).

Figure 8. East of England Regional Biodiversity Map. (**Source**: Saunders & Parfitt, 2005:77)



The result is that the entire region is covered with conservation designations that include:

- Core areas

Then five types of "biodiversity enhancement areas"

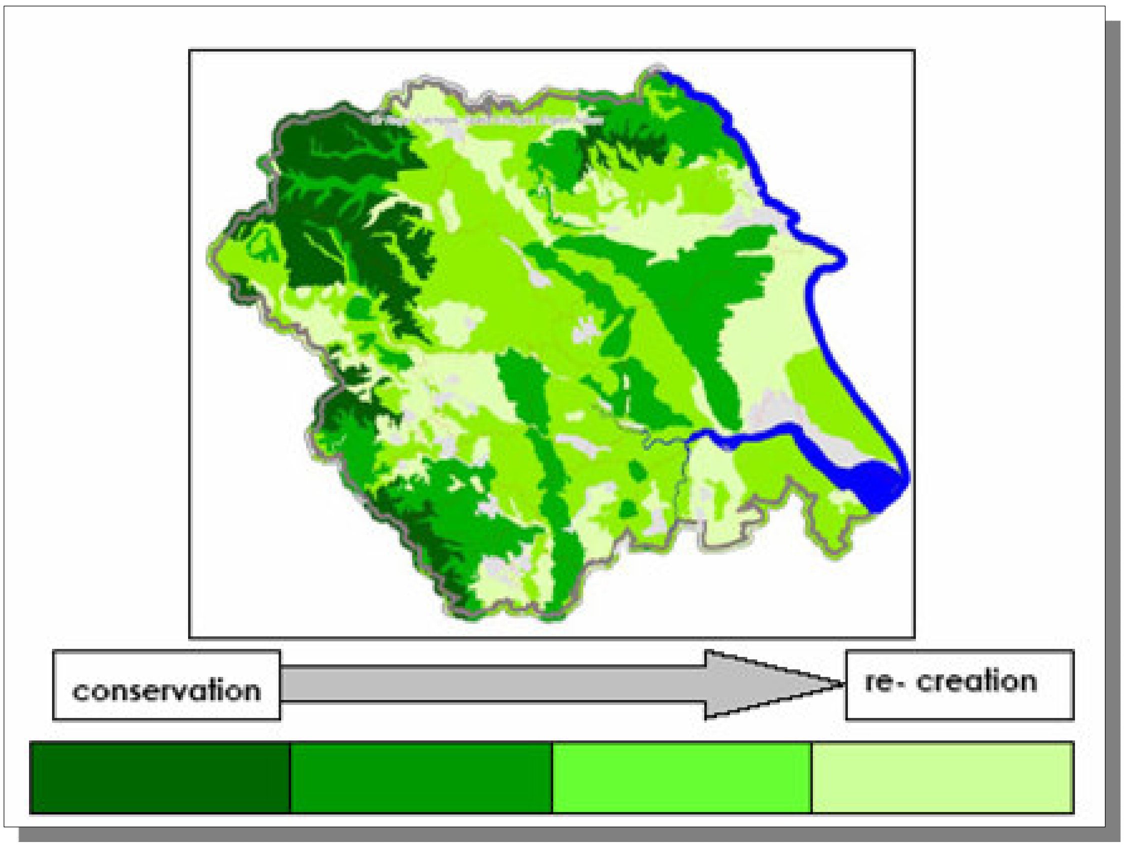
- Buffers for fragmented habitat
- Extensions and links (corridors) for fragmented habitats
- Large-scale habitat restoration and re-creation areas
- Urban biodiversity areas that recognise such areas can provide significant biodiversity enhancement opportunities
- Strategic river corridors that are recognised as important natural ecolinkages in the landscape

These conservation areas closely align with the key components of a landscape ecological approach to strategic biodiversity planning identified in **Table 6 Section 2.2.3**.

Case Study 2 - Yorkshire and Humber Region Strategic Map

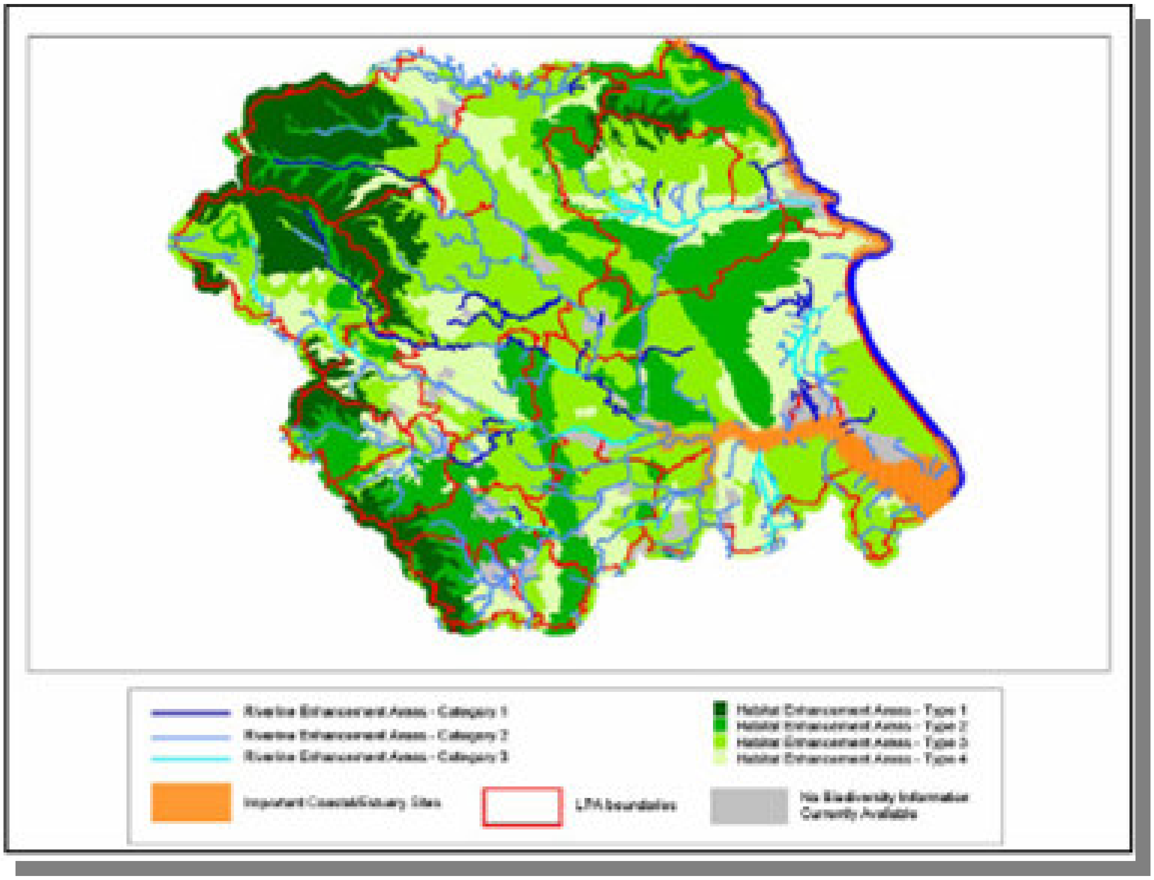
The Yorkshire and Humber Regional Council produced a map representing biodiversity densities within the region as shown in **Figure 9**. This map recognises the continuum of policy and management needs within the region from ongoing conservation in the (dark green) core areas to re-creation in the (light green) highly modified areas.

Figure 9. Yorkshire and Humber Region Habitat Density Map. Dark green indicates highest habitat densities. (**Source**: Catchpole, 2006:25)



This and other information, including Local Planning Authority (LPA) boundaries, are combined to produce the Regional Spatial Strategy (RSS) for biodiversity conservation planning shown in **Figure 10**. An explanatory policy and management matrix that reflects the colour coding accompanies the map. This matrix of policy objectives and implementation options for each zone are shown in **Tables 14 and 15**. This RSS and accompanying policy matrix for biodiversity conservation seek to bridge gap between science and practice by providing guidance for a consistent approach to biodiversity conservation and the integration of landscape ecological thinking in local and regional spatial planning. It does not rely on imposition on authorities of fixed blueprints, an extensive network of local experts, established biodiversity partnerships or expensive project manager.

Figure 10. Yorkshire and Humber Biodiversity Conservation Map. Included in the Draft Yorkshire and Humber Regional Spatial Strategy (**Source**: Catchpole, 2006:28)



A combination of these two approaches inspires part of the LEEP model for biodiversity conservation described in **Chapter 4.** The “Biodiversity Enhancement Area” concept is based on the East of England example. While the graduated conservation zones and policy matrix to guide management decision-making and implementation for each of the identified biodiversity zones are based on that of the Yorkshire/Humber region. Together, each concept is applied in the development of a strategic biodiversity map (**Figure 15** and **Appendix L**) and accompanying policy implementation guide (**Table 24** and **Appendix M**).

Table 14. Policy Framework for Terrestrial and Coastal/ Estuary Objectives, included in the Draft Yorkshire & Humber Region Strategic Map (**Source**: Catchpole, 2006:26)

		BIODIVERSITY CHARACTERISTICS	POLICY DEVELOPMENT	POLICY IMPLEMENTATION
HABITAT AND RIVER/FLOODPLAIN ENHANCEMENT AREAS	TYPE 1	Within Type 1 areas UK BAP priority habitats dominate the landscape. The Region's core biodiversity resource, often of international significance, is in this zone	Policy should recognise, and seek to maintain and restore the biodiversity resource.	Decisions should ensure the maintenance, and wherever possible restores, the integrity of the biodiversity resource.
	TYPE 2	Within Type 2 areas UK BAP priority habitats are less extensive than above, but to some extent they still form a functioning network across the landscape.	Policy should recognise biodiversity networks and seek to strengthen their integrity by expanding patches of high quality habitat, and enhancing links between them. Opportunities for strategic habitat restoration should be sought.	Decisions should seek to expand and enhance networks and should seek opportunities to strengthen them, by contributing to the strategic restoration of habitats.
	TYPE 3	Within Type 3 areas UK BAP priority habitats restricted to isolated sites, separated by large areas of intensively managed farmland and/or urban areas.	Policy should recognise and protect isolated biodiversity features and encourage their expansion.	Decisions should protect isolated biodiversity features and should seek opportunities to expand and buffer them, thereby providing protection from external impacts.
	TYPE 4	Within Type 4 areas UK BAP priority habitats are largely absent.	Policy should encourage recreation and restoration of multi-functional semi-natural habitats.	Decisions should accommodate and allow for restoration of multi-functional semi-natural habitats.
	COASTAL/ESTUARY	The Region's coastline and estuaries are of international importance for species and habitats.	Policy should recognise and enable natural processes to be sustained and the resulting changes to the coastline managed.	Decisions should ensure the maintenance the natural processes are sustained to maintain the integrity of the biodiversity resource.

Table 15. Policy Framework for Riverine Objectives, included in the Yorkshire and Humber Regional Spatial Strategy (**Source**: Catchpole, 2006:27)

		BIODIVERSITY CHARACTERISTICS	POLICY DEVELOPMENT	POLICY IMPLEMENTATION
HABITAT AND RIVER/FLOODPLAIN ENHANCEMENT AREAS	CATEGORY 1	Category 1 represents the Region's core river and floodplain resource where existing features support UK Species of Conservation Priority. Category 1 includes statutory designated sites.	Policy should recognise and seek to maintain and restore the biodiversity resource.	Decisions should ensure the maintenance, and wherever possible, restore the functionality of the biodiversity resource.
	CATEGORY 2	Category 2 represents areas of varied biodiversity quality, where there is a need to improve physical and biological continuity for migratory BAP species.	Policy should recognise river networks and seek to enhance the physical and biological continuity of such ecosystems. Opportunities for strategic habitat restoration should be sought.	Decisions should seek to maintain and restore functional floodplain habitats and associated flooding regimes and avoid obstruction of river continuity.
	CATEGORY 3	Category 3 represents poor riverine habitats in areas of strategic importance for the restoration of the river network and associated biodiversity. It includes some areas of high biodiversity quality.	Policy should encourage recreation and restoration of multi-functional semi-natural habitats.	Decisions should accommodate and allow for restoration of multi-functional semi-natural habitats.

2.4 CONCLUSIONS

A substantial body of scientific work and practical experience has developed in the last 30 years based in the developing field of landscape ecology. Associated with this, considerable international support has grown for landscape ecology and its application as an essential integrative and strategic approach to biodiversity conservation. There are now numbers of credible practical principles or tools available to effectively implement a landscape ecology or ecosystem approach to biodiversity conservation. Connectivity has established itself as an essential key principle for maintaining or restoring functional landscapes. Ecological linkages are proving to be fundamental in developing ecological networks that provide for a fuller range of natural or adaptive movement by species. Because of this sound theoretical base and promising practical application, landscape ecology has gained widespread international application as a strategic, large-scale and integrative approach to biodiversity conservation. The number of regional, inter-regional and continental scale projects based on principles from landscape ecology, particularly ecological networks, continues to grow.

The new English approach to biodiversity conservation is only four years old. However, its pro-active, targeted planning for biodiversity conservation and the use of opportunity mapping, reinforces two broad factors - outcomes and processes – critical for effective and sustainable conservation (See **Table 13**).

The international literature on landscape ecology and widespread application of its principles present a strong case for adopting such an approach in New Zealand to bridge the 'implementation gap' identified in **Chapter One**. This widespread acceptance and its particular practical application in the English land-use planning context offer an opportunity to develop a new model that integrates adaptable aspects from both. **Chapter Four** develops such a model that integrates the following aspects:

1. The design rules for ecological networks described in **Sections 2.2 and 2.3**.
2. The biodiversity conservation maps or 'opportunity maps' and associated policy guidelines described in the English case studies (**Section 2.3.5**).
3. Integrating process from the landscape ecology and English planning that overcome a number of sociological (e.g. landowner/community recruitment) and technical (e.g. definition of ecosystems) challenges to implementing more effective and sustainable conservation outcomes (**Table 4 Section 2.2**, and **Sections 2.2.6** and **2.3.3**).

CHAPTER THREE – NEW ZEALAND CONTEXT

3.1 INTRODUCTION

A thousand years of human habitation has radically altered the New Zealand landscape – how have we responded to this loss and the recent thinking on ecosystem conservation and the international development of the discipline of landscape ecology?

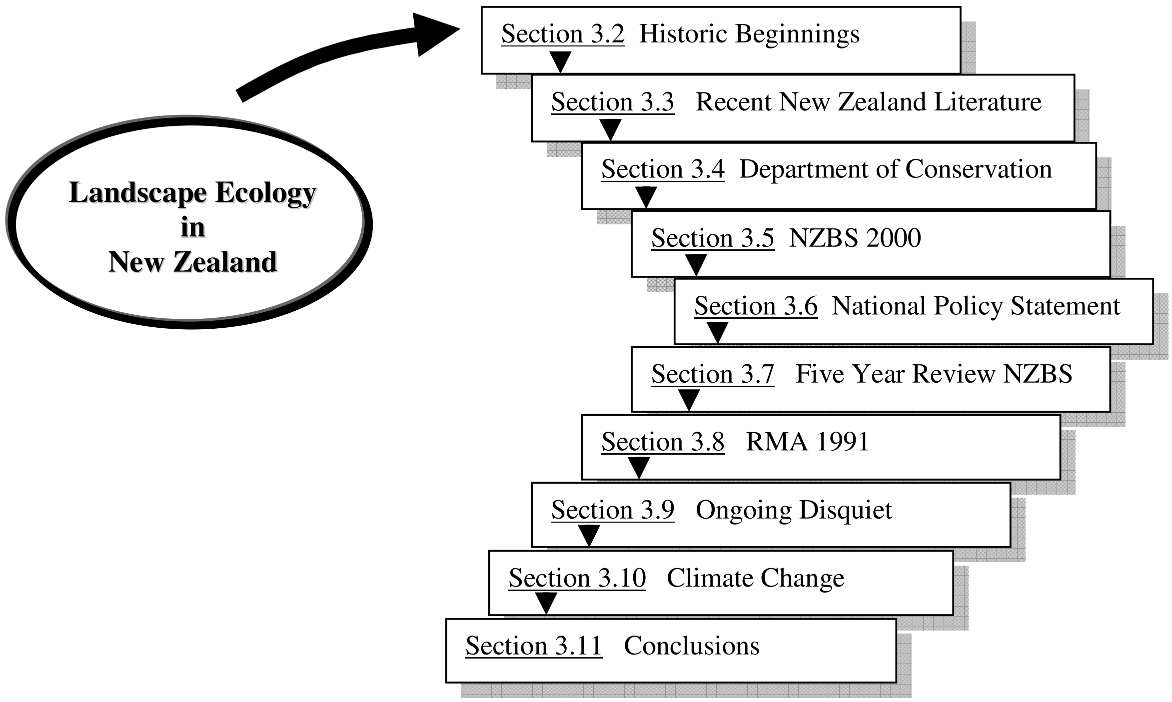
The modern history of conservation in New Zealand began with the protection of the natural environment for scenic purposes rather than protection of species and ecosystems. Since then, several models have been applied – and continue to be applied - to conserve biodiversity resources:

- Establishment of National Parks to protect outstanding scenic resources and indigenous remnants – most often in remote, topographically hostile and agriculturally less attractive areas
- Pioneering the establishment of offshore island sanctuaries – clearing them of introduced mammalian predators and relocating and nurturing native species threatened on mainland sites
- Pioneering, also, single-species recovery programmes, often on island sanctuaries, to retrieve species threatened by loss of habitat and the introduction of predators and invasive plants
- Development of animal and plant pest management programmes to combat impacts on the primary production sector and native flora and fauna
- Development of new policy and legislative initiatives to better protect natural resources.

Unfortunately, all of these have been insufficient to halt the decline of New Zealand's biodiversity, as discussed in **Chapter 1.**

One area of biodiversity conservation noticeable by its absence from New Zealand practice, if not policy, is an ecosystem or landscape ecology approach. This section canvasses the institutional and academic literature and context in which conservation policy and practice has evolved and recent efforts to broaden conservation practice beyond traditional methods. **Diagram 8** depicts the structure and flow of this section and its contents. This section also provides the necessary background for the case study in **Chapter 6** that applies the new 'LEEP' model for strategic biodiversity planning.

Diagram 8. Structure of New Zealand Literature Review



3.2 HISTORICAL BEGINNINGS

David Young (2004:13) describes how there were some in calls, in the post-Treaty years, to protect indigenous flora and fauna, *"But the overriding ethic of this time was the destruction of indigenous biota on the lowlands especially, and the acclimatisation of introduced species"*. New Zealand's pioneer conservation guidance was eventually taken from the United States, particularly the idea of national parks: A national preservation policy developed to protect Yellowstone in 1872 that had a significant influence on the origins of New Zealand reserves. Fifteen years later, 1887, New Zealand got its first national park – Tongariro.

Like America, New Zealand's 'first generation' national parks were set aside for aesthetic and not ecological reasons. Also like America's national parks and reserves, the design of New Zealand's parks and reserves boundaries did not reflect ecosystems nor any understanding of maintaining a functional landscape. Therefore, New Zealand national park boundaries – perhaps best demonstrated by the near symmetrical shape of Egmont National Park illustrated in **Figure 11** – show the same artificial shapes and man-made short-comings characterised in the earlier sections of this study on the development of landscape ecology.

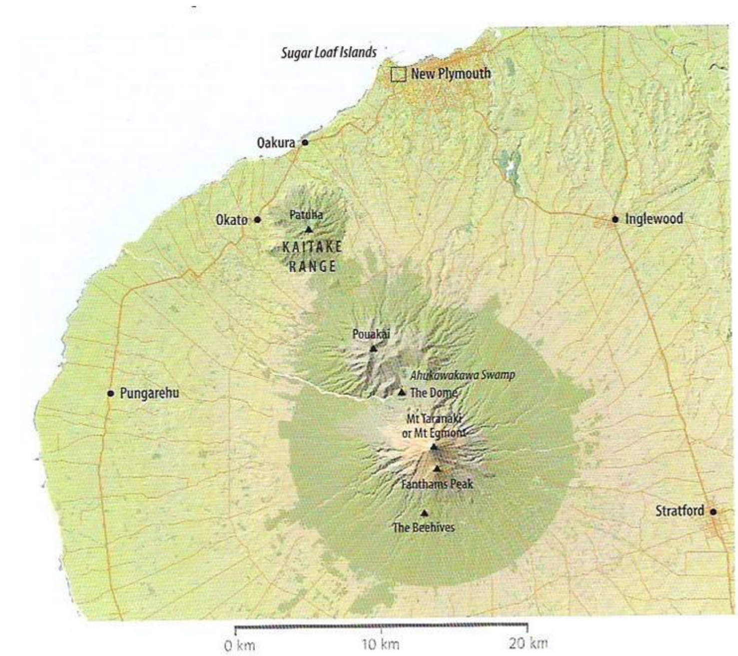


Figure 11. The Artificial Symmetry of the Boundary of Egmont National Park. Shown by the precise 'transitioning' from native forest (green) to surrounding pasture (olive) – exemplifies the historic non-ecological foundation and nature of reserves in New Zealand. (**Source**: Malloy & Smith, 2002:46)

However, throughout the nineteenth century, any interest in native flora and fauna was, generally, only scientific. But by the end of the century scientific societies had achieved a conservation milestone of national and international significance - convincing the government to reserve a number of island sanctuaries where endangered birds could be placed and protected from predation by introduced species. Their development was stimulated by a small scientific community that realised that the loss of native habitat had *"created the what is now seen as one of the most devastating, and rapid losses of bird species in the history of the planet."* (Young, 2004:13).

By 1903 scenic reserves had their own law, but these were designed to protect scenery and historic heritage. Only in later years did they come to protect habitat and wildlife and finally form the foundation of national parks (Young, 2004:13).

> *"Lands and Survey was clear that parks were essentially land for a public good use where 'vested interests' and commercialism had a limited role. They 'are established for the well-being of the nation and are to be preserved so far as humanly possible in their natural state so that the people may receive in full measure the inspiration and benefits that mountains, forests, lakes, and rivers have it in their power to give'."* (Young, 2004:125-126, citing the Appendix to the Journals of the House of Representatives 1933, 1938)

However, this reality made no impact and unrestrained habitat and land development continued until the1950's when the devastation of flooding and mass soil erosion necessitated the enactment of the Soil Conservation & River Control Act 1941 and the precursor to the Wildlife Service (Young, 2004:14).

The wilderness provisions of the National Parks Act 1952 came from America (Young, 2004:152, citing David Thom from Heritage p.216). Introducing the Bill, the Minister of Lands, Forests and Maori Affairs spoke of national parks serving to protect native forest and acting as sanctuaries for native birdlife. They were also to *'preserve these areas in all their pristine beauty'* for recreational use (Young, 2004:152, citing from New Zealand Parliamentary Debates. Vol.297, 5 Aug 1952, pp 713-715).

The stated purpose of the original National Parks Act 1952 was

> *"… preserving… for <u>the benefit and enjoyment of the public</u>, areas of New Zealand that contain <u>scenery</u> of such distinctive quality of natural features so beautiful or unique that their preservation is in the national interest."(National Parks Act 1952, s3(1))*

The focus of protection was clearly scenery and public enjoyment, a view shared by New Zealand conservationist Sir Charles Fleming (Young, 2004:152, citing Charles Fleming, 'The History and Future of the Preservation Ethic', National Parks of New Zealand, Conference Proceedings, National Parks Authority Series No.14, Wellington, 1979, p.61). This 1952 approach to national parks was only broadened out to include distinctive landforms and representative ecosystems in 1980 with updated national parks legislation (Young, 2004:152)

The loss of over 70% of New Zealand's original forest cover, most of it lowland, and the massive loss and fragmentation of habitat that implies, has already been dramatically illustrated by **Figure 1** in the introductory chapter.

3.3 RECENT NEW ZEALAND LITERATURE

More recently, Ogle (1989) in "An Overview of Reserve Design and Location in New Zealand" in a major Ecological Society of New Zealand publication on *'Management of New Zealand's Natural Estate'*, endorsed larger patch sizes stating that the New Zealand experience confirms larger patches have greater habitat diversity and a trend towards more species, than in smaller patches. He acknowledged the debate at the time about the effectiveness of corridors, but cites Diamond's (1975) principles and suggests small patches should be linked to large patches by corridors, or actively managed (p11-12). He also refers to considerable positive field research on corridors in Australia, and that they especially facilitate movement between discrete patches, road verges and watercourses.

Interestingly, on the corridor debate in New Zealand, Ogle in the same paper refers to a one-day RSNZ workshop in 1983 on reserve design in New Zealand (citing McIntyre et al. 1983) in response to island biogeographic theory. An 'audience vote' was taken on which criteria for better reserve design could they as representatives of the '*concerned scientific community'* of New Zealand, endorse as worth retaining? Only "large areas" received unqualified support (citing King 1983). Concepts of patch shape and proximity, including corridors to link patches, were considered to be 'unproven' or to be valid only under certain conditions. As far as this author knows, the Royal Society has not revisited these issues of reserve design, island biogeographic theory and their application to New Zealand, despite significant development in the theory, practice and experience in conservation biology and landscape ecology.

Ogle championed island biogeography as a valuable conservation tool noting that island biogeography had been used to protect *"considerable areas"* overseas before *"serious doubts"* about the theory began to arise in overseas literature (*op.cit.* p.13). He believed too little analysis had been done of data for ecosystems in a biogeographic framework other than native forest. Ogle championed island biogeography (and still does - pers.comm. 2007) as a valuable conservation tool (*op.cit.* p.13), and concluded,

> *"Despite criticisms of many aspects, certain reserve design principles have been shown to hold for native forest bird habitat on mainland NZ. No evidence has undermined the basic findings, for example, on patch size, proximity to other patches, or altitudinal ranges. Island biogeography gives quick and relatively conservative answers when other data are not available."* (Ogle, 1989:15-16)

Potter (1990) studied the use of stepping stone habitats by Brown Kiwi in Paerata Reserve, North Island. At night, Brown Kiwi foraged outside the reserve crossing gaps of over 120m open pasture to access outlying remnants – one individual moving 1200m from the reserve boundary by using three intermediate remnant patches to reach a fourth. Potter's work suggests that stepping stone patches of forest at suitable intervals (i.e. 100m or less) can ensure functional connectivity of habitat for kiwis living and foraging in fragmented landscape. Potter proposes, *"The planting and/or protection of small islands of forest adjacent to kiwi reserves is recommended as a method of linking forest remnants together and increasing the effective size of reserves."* (Potter, 1990:17)

In discussing the implications of his work on Brown Kiwi, Potter concluded and urged that despite unknowns:

> *"…it is important not to let ignorance of these matters prevent us from acting now on the information we have (see Diamond, 1986). I have shown that kiwi will use forest 'stepping stones', and that kiwi habitat can be enhanced if land owners are encouraged to retain and protect forest remnants near kiwi reserves. We need to apply these principles elsewhere and, as Janzen (1986) urged, learn to be as concerned about the composition of the surrounding habitat as we are about reserves themselves. Remaining inactive may send many of our remaining kiwi populations to extinction.*" (Potter, 1990:23.)

Clearly, there was strong early support for establishing ecological corridors or stepping stones to enhance biodiversity conservation outcomes.

Thomas (1991) from the Centre for Population Biology at Imperial College, London undertook a review and assessment of ecological corridors for DOC. He acknowledged the criticisms of Simberloff and Cox (1987) and the potential benefits and drawbacks, including those recognised by Noss (1987). His conclusion was that each proposed corridor needed to be judged on its own merits (p.22). Thomas described the positive use of a corridor system by the then New Zealand Forest Service to link isolated indigenous forest areas in the Paparoa Range/Southern Alp area around Reefton. Here existing reserves were protected and additional reserves recommended to form ecological corridors connecting the reserves.

O'Donnell (1991), more usefully perhaps, undertook a more detailed assessment of the application of the wildlife corridors concept to the same forest area of the Paparoa Range as referred to by Thomas above. The need for wildlife corridors in 1986 was used to justify interim conservation of extensive areas of temperate rainforest zoned for logging. The Paparoa Range (150,000ha) otherwise isolated by rivers and a matrix of agricultural land, is joined by a lowland forest corridor (50,000ha) to outlying ranges of the Southern Alps. O'Donnell concluded that corridors were justified for aiding long-term gene flow and genetic variation of bird species (p.83). Other conclusions were equally more positive than Thomas' assessment and included:

- The general concept of a wildlife corridor appears to be a useful conservation tool on a regional scale where connected reserves would otherwise become isolated. (p.96)

- Corridor proposals should be individually assessed. If this is NOT possible, the international literature suggests that, in general, "corridors are a prudent conservation strategy."
- The effectiveness and value of corridors is likely to differ for each group of animal.
- The corridor system should contribute to the maintenance of existing bird species diversity by providing contiguous areas large enough to support viable populations of key species, and by linking food patches and high and low altitude habitats.
- The corridors seem to be most important for eight of the 31 bird species present (i.e. great spotted kiwi, kaka, yellow-crowned parakeet, rifleman, brown creeper, yellowhead, tomtit, and robin. He believed that in the Paparoa situation these key species acted as indicator species because:
    - They obtain the most benefit from the corridor
    - They have the largest home range requirements and the most specialized habitat preferences
    - By catering for their needs, the requirements for other birds should also be met

This work of Ogle, Thomas and O'Donnell show that there was a mixed response to a strategic spatial approach to wildlife habitat planning, but that there was still strong support from at least some scientific quarters in New Zealand for a biogeographic approach.

3.4 DEPARTMENT OF CONSERVATION

About this time, Auckland University undertook a local and nationwide survey of public appreciation of and attitudes towards conservation management in New Zealand (Craig, Craig, Murphy, & Murphy, 1995). Interestingly, contrary to the 'popular' and prevailing focus on species recovery programs by New Zealand's conservation agencies, public opinion showed an overwhelming preference for ecosystem management than solely individual species management. Part of the survey polled DOC staff, who consistently ranked ecosystem protection lower in priority than species.

Two conclusions of Craig *et.al* from the survey were that DOC did not manage conservation issues in a way that the public wanted and that DOC conservation staff saw themselves as 'government servants' rather than 'public servants', which did not bode well for the future effectiveness of conservation.

Concerned by the results of the Craig *et al*., DOC undertook its own survey in the same year (1992), only to confirm the results (Pers.comm. Craig 2006). The Department responded with a 'declaration of strategic intent' which affirmed a need to consider ecosystem management as the primary unit for action and that species work needed to include whole ecosystems. However, John Craig (Pers.comm.2006) believed little had changed in DOC's approach to conservation in the intervening fifteen years. Other events and documents would seem to bare this assessment out.

Calls by Geoff Park and others for an ecosystem or landscape ecology rather than a species-based approach to biodiversity conservation, during a DOC Science and Research Division seminar series on biodiversity in 1994 (Department of Conservation, 1996a) were ignored and have continued to be largely ignored (Pers.com. Simpson and Park 2007). First generation Conservation Management Strategies (CMS) developed by the then thirteen Conservancies (e.g. the Wellington Conservancy, Department of Conservation, 1996b), contained important references and policies consistent with an ecosystem or landscape approach to biodiversity conservation, and required to development of restoration strategy. However, these CMS policies represented an ideal rather than the funding reality. They were never linked to budgetary objectives, and were consequently never implemented (Pers.comm. Flavell and Miskelly 2007).

Simpson's (1997) report for DOC addresses the need to recognise ecological restoration as means to include a restoration strategy within the CMS for the Wellington region. Based on the principles of landscape ecology (Pers.comm. Simpson 2007) the report describes, "*general opportunities for restoration… for both protected and un-protected land.*" His recommendations included establishing buffer zones and ecological corridors to protect and connect core and remnant patches of indigenous vegetation and habitat (p.1). The Conservator's Foreword to the report acknowledges,

> *"…that in the future the protected land and the productive land will need to be managed as a whole so that ecological processes across the landscape are restored and maintained."*

The Conservator goes on to say, however, that

> *"The Department is already working on a number of recommendations. Others are valid but have low priority at present given existing tasks, especially in species and predator management. Together, however, the Recommendations offer a strategic*

> *direction that can be implemented as time and resources become available."* (Foreword to Simpson, 2007:v)

This response is consistent with previous observations about DOC's priorities and performance in ecological restoration at the landscape scale. The focus remained on species recovery and predator control and the recommendations of Simpson's report were never actioned due to "insufficient resources" (Pers.comm. Simpson 2007).

Park (2000) also produced a report for DOC – '*New Zealand As Ecosystems'* - in which he promotes a larger-scale, landscape ecology approach as the only way to conserve the overwhelming mass of species (p.81-82). He recognises that the essential element in such large scale approaches is an emphasis on connectivity (p.82), a view also promoted by Atkinson in an unpublished presentation to DOC in April 1995.

Park considers that a regional landscape approach to biodiversity conservation would be a 'sea change' to current prevailing philosophy, and challenges…

> *"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?"* (Park, 2000:87.).

Park's report, like that of Simpson's, was never acted on (Pers.comm. Park 2007).

3.5 NEW ZEALAND BIODIVERSITY STRATEGY 2000

If there was any merit in the ecosystem or landscape ecology approach to biodiversity conservation, one would expect to form part of the content and objectives of the New Zealand Biodiversity Strategy (NZBS) (Department of Conservation, 2000).

The NZBS echoes the assessment of earlier State of the Environment Report that, *"…decline of New Zealand's indigenous biodiversity [is] our most pervasive environmental issue."* (p. i.). The Report repeatedly recognises the impact of ecosystem fragmentation on species loss.

> *"Species losses are often the result of an even more pervasive loss - that of natural ecosystems and habitats. Changes in New Zealand's landscapes have had a dramatic impact on New Zealand's biodiversity. Sixty-three percent of New Zealand's land area has been converted into farms, exotic forests, settlements and roads. A once continuous range of unique ecosystems has been turned into a patchwork of isolated fragments."* (p.6)

Other relevant points made in the NZBS include:

- Insufficient and fragmented habitat is considered alongside invasive species as the key threat to indigenous species (p.35)
- Tendencies towards separating management of species from their habitats (p.36)
- Attention and funds have focused on a small number of highly threatened, and often most visually appealing, native species while many populations of threatened species continue to decline (p.39)
- Threatened species management has not always been well integrated with habitat protection and management on public and private land (p.39)
- Reduction and fragmentation of indigenous species populations has eroded genetic diversity (p.39).
- Priority setting for biodiversity management (including threatened species management, habitat protection and restoration, and threats control) is not yet coordinated across various management agencies. (p.39)
- 'Ecosystem Management' is recognised as the preferred approach to sustainable and effective biodiversity conservation and restoration. It is describes as a holistic approach that accepts human activities as part of the ecosystem, and that the use of natural resources should be used in a way that recognises ecological processes. (p.108, 111)
- Public conservation land does not contain the full range of indigenous terrestrial ecosystems and any effective strategy to conserve biodiversity must involve both (p.126-127)
- While many landowners are receptive to contributing to New Zealand's biodiversity goals, they need assurance that their efforts will contribute to a coherent larger programme. (p.127)

In a significant section on 'habitat fragmentation', the NZBS makes the following observations:

> *"Fragmentation of natural areas through ongoing land use changes has produced many isolated remnants that are important for biodiversity but vulnerable to continuing degradation, including invasion by pests and weeds and loss of indigenous species.*
>
> *"There is a need for greater recognition and action to restore fragmented, degraded or scarce natural habitats, halt declining ecological condition, restore essential ecosystem functions and extend the area of particular habitat types.*

> *"Restoration initiatives on both public and private land are currently constrained by gaps in knowledge about ecological processes and restoration techniques (for example, the use of corridors), a lack of incentives, and a shortage of information, practical guidelines, expertise and resources.*
>
> *"There is a need for greater recognition of the opportunities to maintain, restore and reconnect fragmented, degraded or scarce habitats for indigenous species through the sympathetic management of production land and urban areas."* (Department of Conservation, 2000:38)

As a result of this kind of recognition, "*Goal Three: Halt the decline of New Zealand's Indigenous Biodiversity"* of the NZBS states an aim to:

> *"Maintain and restore a full range of remaining natural habitats and ecosystems to a healthy functioning state, enhance critically scarce habitats, and sustain the more modified ecosystems in production and urban environments; and to maintain and restore viable populations of all indigenous species and subspecies across their natural range and maintain their genetic diversity."* (p.6)

The NZBS clearly envisaged restoration and enhancement as part of the future biodiversity conservation agenda. The "Action Plan" for "Biodiversity on Land" (p.33-44) describes a desired outcome for 2020 that includes:

> *"Scarce and fragmented habitats (such as lowland forests and grasslands, wetlands and dunelands) have increased in area and are in better ecological health due to improved connections and the sustainable management of surrounding areas.* (p.33)

Despite the recurring theme of habitat fragmentation as one of the most significant factors in the decline of indigenous biodiversity and the explicit intention to undertake landscape reconnection, this does not seem to be explicitly recognised in the Action Plan objectives for land-based biodiversity. Fragmentation, connectivity, corridors etc are not explicitly mentioned in the relevant objectives (p.41-44). Instead, Objective 1.1 Protecting indigenous habitats and ecosystems, sets out two objectives (p.41):

> *a) Enhance the existing network of protected areas to secure a full range of remaining indigenous habitats and ecosystems*
>
> *b) Promote and encourage initiatives to protect, maintain and restore habitats and ecosystems that are important for indigenous biodiversity on land outside of protected areas.*

However, this falls far short of a commitment to any comprehensive or strategic approach to any ecological restoration plan at any level - local, regional or national.

3.6 NATIONAL POLICY STATEMENT ON BIODIVERSITY

A key action point from the NZBS was the need to develop a National Policy Statement (NPS) on Biodiversity. Preliminary wording for the NPS (Ministry for the Environment, 2001) identified maintaining and enhancing ecological functions as a key priority stating:

> *Halting the decline of indigenous biodiversity requires more than just identifying museum pieces and targeting these for attention. Making progress requires us to look at the wider environment to see how various components can assist. It also means restoring connections between presently isolated fragments of natural ecosystems. The approach taken is to identify priority systems and to focus on maintaining or enhancing the ecological functioning of those systems. The approach also encourages restoration and rehabilitation of systems where ecological functioning has been impaired."* (p.5)
>
> *The fragmentation of New Zealand's indigenous ecosystems has increased the vulnerability of our endemic species to extinctions. Small patches of indigenous vegetation often cannot support the minimum number of individuals necessary to maintain a population. Fragmentation can destroy migration routes and sources of food and impede the movement of seeds.* (Issue 3.2 Fragmentation, p.13)

The preliminary NPS proposed the following associated objective:

> *To maintain and enhance connections within, and corridors and linkages between, ecosystems that are important for the passage of indigenous fauna and/or the transmission of seeds of indigenous species.* (Objective 3.2, p.13)

No NPS for biodiversity was forthcoming, six years after it had been signalled in the NZBS. Despite Green and Clarkson's (2006) review of the NZBS making a strong recommendation that a NPS on biodiversity was essential to provide added guidance to local and regional authorities in achieving biodiversity conservation goals (p.1&17), development of the NPS has now been abandoned. Instead, MfE and DOC have now recently released a *'Statement of National Priorities for Protecting Rare and threatened Biodiversity on Private Land'* (Ministry for the Environment & Department of Conservation, 2007). This document will not deliver the kind of effective strategic and practical direction anticipated by an NPS and has received a mixed reception from practitioners (e.g. a presentation at the DOC-sponsored '*Conserv-Vision* Conference' in July 2007). It certainly does not provide much in the way of the kind of strategic ecosystem approach hoped for, nor likely to produce the claimed 'stability and resilience' for native species and ecosystems.

DOC's recent *'Statement of Intent 2006-2009'* (Department of Conservation, 2006) suggests a continued emphasis on pest control (p.19-20), while acknowledging the effects of landscape fragmentation (p.49), intentions to protect habitat remnants are small-scale (p.58-59), and the key initiatives for the planning period do not mention any ecological restoration objectives.

3.7 NZBS - FIVE YEAR REVIEW

Interestingly, the recent review of the first five years of the NZBS, *"Turning the Tide?"* (Green & Clarkson, 2006), fails to mention anything with regard to progress or otherwise on the issue of connectivity highlighted in the NZBS. The increasing importance of "corridors", however, is recognised in connection with the impacts of climate change on terrestrial biodiversity (p.20). The Review considers the national biodiversity focus remains on offshore islands and species protection.

Despite successes in the implementation of the NZBS, the Review estimates there has been a loss of indigenous ecosystems of 4,500ha per year between 1998 and 2002 (p.16). On a Radio New Zealand National interview on the Review, Green summarized this as a 28,600ha loss in a five-year period and likened this to losing an area the size of Abel Tasman National Park (National Radio Thursday 15 March 2007 3:45pm). Green & Clarkson believe this rate of loss is continuing.

Green and Clarkson's assessment of ongoing loss of indigenous cover is backed by Walker et.al. (2006) from the recently developed national spatial databases – LENZ: Land Environments of New Zealand and LCDB: Land Cover Databases. Improved estimates of terrestrial indigenous cover show that 49% of 'environments' have lost indigenous cover between 1996/7 and 2001/2, and that the highest rates of loss have occurred where indigenous cover was already most depleted (p.169). The authors make the point that *"these much-reduced areas of indigenous cover remaining in these threatened environments* (coastal, lowland and montane) *support a disproportionately large percentage of New Zealand most seriously threatened specie*s" (p.175). The authors conclude their data suggests,

> *"…that public awareness and education, voluntary protection, Resource Management Act (1991) provisions, and formal legal protection of remaining indigenous biodiversity have not halted the removal and/or displacement of vulnerable indigenous biodiversity in much reduced and poorly protected ecosystems and habitats."* (Walker et al., 2006:175)

New Zealand is still losing significant amounts of indigenous cover and with it significant parts of its biodiversity resources. Biodiversity conservation activity to date has not been sufficient to curb this loss.

3.8 RESOURCE MANAGEMENT ACT 1991

If there have been continued shortcomings in any strategic ecosystem approach to biodiversity conservation from New Zealand's public conservation agency, any hope that the enactment of the Resource Management Act 1991 (RMA) would make a significant difference with its emphasis on ecosystem protection (Park, 2000), has been ill-founded. Froude (1997) reviewed local and regional authority performance in meeting statutory obligations under the RMA relating to the protection of ecosystems and biodiversity. Froude concludes that the various approaches adopted by local authority lacked consistency and were often *ad hoc*. Froude identified a lack of any national coherent integrating direction on biodiversity to guide local authority work.

3.9 ONGOING DISQUIET - FURTHER NEW ZEALAND WORK

There have been a number of recent works on the application of a landscape ecology approach within the New Zealand context.

Viles & Rosier (2001) reviewed the neglected area of the impact roading has on wildlife habitat and ecosystems and the potential for the same roading network to make a significant contribution in reconnecting fragmented landscapes. They describe roads as, *"…one of the most destructive elements in the fragmentation process"* (p.15). Their study analysed the potential for applying principles from landscape ecology and connectivity concepts to provide an integrated approach to managing New Zealand road reserves and the adjacent landscape to assist the extension of ecological corridors to overcome the adverse effects of roading networks. They suggest a *"coordinated approach between conservation managers, road construction and management authorities, local government, utility managers, landowners and others who have an interest in roadside management… if integration is to be successful"* (p.1). They also recommend a change in road design within reserve areas to consider not just road safety but also the landscape context and the needs of species moving through the landscape.

Calder *et al*. (2002) applied elements from landscape ecology to produce a structure plan of the *Whanganui* Catchment. This plan identified a range of resource development activities and preferred locations, while identifying ecological corridors and buffer zones to connect large but semi-isolated native forest remnants and national park areas. Such an opportunity is described as a plan for both sustainable regional development and protection of the ecological integrity of indigenous species and habitat. It was noted, however, that not only did the regional resource management agencies have no plans for a similar study, but also were unlikely to be able to coordinate such an approach (author's observation).

Eikaas e*t al*. (2005) demonstrated the adverse effects of terrestrial habitat fragmentation on riverine edges and freshwater fish. Their research showed that, *"the total length of stream affected by land use change such as forest clearance is generally longer than the length of stream directly affected… the impacts on stream ecosystems often manifests themselves in a downstream direction*." (p.6) and that edge effects are impacted by the size and shape of remnant patches. They concluded that, *"… reestablishment of wide forest margins around pastoral streams may significantly improve the extent of their distribution in developed catchments"* (p.6).

Walls *et al.* (2005) undertook an ecological survey of South Marlborough. Their recommendations to the District Council form what is essentially an ecological restoration plan for the area. Noting that the *"…very depleted and many remaining sites are small and fragmented*" their recommendations include,

> *"…A landscape approach to restoration, whereby fragmentation is gradually reduced, is an important principle, building on the natural tendency for forests to regenerate along streams"* (p.72).

Freeman (2003) reviewed what she considered inadequate indigenous habitat protection with particular reference to coastal plains areas of New Zealand dominated by production landscapes. These are areas where less than 5% of the original native vegetation remains. She notes, *"the continuing loss of lowland habitat remnants is recognised in the NZBS (2000) as one of the most intractable of New Zealand's conservation problems."* Her research showed a majority of sites with conservation values were not included in existing conservation databases and therefore not subject to conservation planning and management processes.

In response, Freeman reviews the opportunity offered by integrated bioregional or landscape-level approach to conservation planning that addresses habitat fragmentation through use of local and regional ecological networks or corridors (p.187). Freeman refers to the widely accepted ECONET ecological network approach used in Europe to integrate social and economic factors into the development sustainable management of landscapes (p.187). On the use of corridors in New Zealand, Freeman observes:

> *"The development of corridors at the regional scale in New Zealand… has received little attention in conservation planning. Certainly there are no initiatives integrative in type or regional scale that resemble the ECONET programme. To date New Zealand has not developed a regional approach that recognizes ecological regions or bioregions as a planning base, nor has it developed a genuinely strategic conservation planning framework."* (Freeman, 2003)

Among Freeman's concerns is DOC's lack of involvement in biodiversity sites outside the 30% land area administered as conservation estate and "*no legislative requirement for co-ordination of biodiversity between the DOC and local authorities, or for the co-ordination of the conservation of biodiversity on private and DOC land"* under the Resource Management Act 1991. Freeman believes this division of responsibility for land-use conservation provides particular difficulties for any kind of strategic conservation planning in lowland areas especially impacted by multiple land-uses and landowners (p.188).

Despite provisions in the RMA for Regional Policy Statements and National Policy Statements and New Zealand being a signatory to the Convention on Biodiversity that requires signatories to move towards a much broader-based ecosystem-type approach to conservation planning, Freeman concludes:

> *"In reality there is at present little evidence of the adoption of strategic thinking in New Zealand's conservation planning at either national or regional level. This is reflected in the latest documentation released by the New Zealand government, namely, The* New Zealand Biodiversity Strategy *(DOC & MfE, 2000),* Bio-what *(MfE) and* Weaving Resilience into our Working Lands *(Parliamentary Commissioner for the Environment, 2001). These documents include useful policy guidance strategies on the promotion of native habitats, particularly on private land, but provide no guidance on or requirement for spatial and policy planning at a more strategic level… In New Zealand there is, characteristically, a disjuncture between the approach to conservation planning as expressed in policy and legislation and the need for the landscape to be restored where appropriate to a previous condition… In New Zealand, conservationists characteristically adopt a site-focused approach based on identified conservation values rather than adopting a strategic approach that recognizes the integrated multi-faceted nature of the landscape."*(Freeman, 2003:188-189)

Freeman finally concludes:

> *"…if the decline of native habitats on the plains is to be halted and reversed, a new approach to conservation planning is needed. A strategic planning approach to conservation is required, based on ecological regions where the focus is on co-ordinated planning of natural areas at the landscape scale.*(Freeman, 2003. from Abstract)

These kinds of work and their conclusions demonstrate an ongoing recognition of the potential benefits of a more strategic, larger-picture, integrative approach to biodiversity conservation in New Zealand. They also indicate there is already a pool of expertise available in New Zealand to advise on a fresh an approach to biodiversity planning. The same works, however, also illustrate the *ad hoc* nature of the work and a recurring frustration at the inaction of institutional resource management agencies to develop and implement any effective ecosystem-based approach. Fundamentally such a strategic approach is seen by these institutions as only an 'add on' once traditional conservation methods and resource demands have been met. Compare this attitude to that of the most recent international publication on connectivity conservation where Crooks and Sanjayan (2006:13) note that habitat loss and fragmentation have been identified as major threats to life on the planet, and maintaining connections in otherwise fragmented landscapes has become a primary focus of international conservation effort. These issues, considered critical elsewhere, have had a much lower profile in New Zealand, despite intentions to the contrary in documents such as the NZBS and other scientific and policy documents. The critical issues of maintaining connectivity in nature has had a strong appeal to planners, politicians, and land managers worldwide, except… in New Zealand. It seems there is a serious need for a landscape ecological or ecosystem approach to be accepted as 'mainstream' for effective progress to be achieved.

3.10 NEW ZEALAND BIODIVERSITY AND CLIMATE CHANGE

Climate change and its likely impact on biodiversity in New Zealand, is an issue where a landscape approach to biodiversity conservation can make a significant contribution to biodiversity outcomes and mitigation of factors contributing to global warming.

Climatologist McGlone (2001) reporting for the Ministry for the Environment on the *"Linkage Between Climate Change and Biodiversity in New Zealand"* makes several important points (p.5-6):

- There is a strong possibility that the New Zealand climate will change substantially and inevitably impact on indigenous biodiversity and ecosystem functions through the direct effects of increased CO_2 levels, warming, precipitation changes and increased frequency and severity of extreme events.
- The buffering effect from the adjacent sea will mean that climate change in New Zealand will lag average global warming. However, wind and temperature changes will produce

significant regional climate variation: A warmer north, increased rainfall in the west and drier conditions in the east that will increase current climate gradients (p.8-9).

- Climate change will have the greatest impact on small patches of fragmented habitat with low resilience due to increased exotic weed and pest pressure and disruption of ecosystem processes (p.5-6, 24-25).
- The potential for restoration in the eastern rain-shadow districts will be adversely affected. Some areas may become too dry to support indigenous forest and effectively prevent any chance of reversing habitat loss (p.23-24).

McGlone *ibid* observes that present and future climate change is rarely taken into account in biodiversity planning, and strongly recommends explicit consideration in decisions made on priorities for both species and ecosystems. He also recommends consideration be given to facilitate movement of plants and animals southwards to address biodiversity loss in the north caused by climate change. He encourages planting of new forests (indigenous, exotic or mixed), expansion of existing indigenous forest, and wetland restoration to offset the New Zealand carbon footprint, which would also have benefits for indigenous biodiversity in expanding large continuous tracts of indigenous vegetation to enhance functional ecosystems. He strongly promotes the need to integrate biodiversity issues into carbon sequestration planning (p.5-6).

McGlone's conclusions are reinforced by a report of the New Zealand Climate Change Office and the Ministry for the Environment (2004) which includes a warning:

> *"Increased temperature, reduced rainfall, and more frequent drying westerly winds (possible in the east) could lead to changes in distribution and composition of native forest ecosystems throughout New Zealand. Most vulnerable will be fragmented native forests in the north and east…"* (p.26)

Green and Clarkson (2006) in their five year review of the NZBS highlight that it does not address climate change and recommend a new section be added to address the impact of climate change on biodiversity (p.2 and 46).

It is clear, even at this early stage, climate change will have an impact on indigenous cover, wildlife habitat and ecosystems. Currently, inadequate consideration and planning has occurred to address these likely impacts. A strategic landscape-scale approach to biodiversity conservation has a potential significant contribution to facilitate species and ecosystem migration southwards and to higher altitudes.

3.11 CONCLUSIONS

Ongoing calls for an ecosystem or landscape-scale approach to biodiversity conservation in New Zealand have been largely ignored by key agencies. Despite recognition of landscape ecological principles in national policy documents such as the NZBS, no guidance or unction towards implementing such a direction has been forthcoming and on-the-ground implementation has been *ad hoc* and inconsistent. Traditional conservation methodology continues to dominate conservation practice and little change has occurred in strategic conservation planning in the seven years since the NZBS.

Resistance to implementing a landscape approach to biodiversity conservation in New Zealand is due to several factors, but can be summarized under a lack of guidance, professional capacity and a funding. By inference, this also suggests a lack of leadership from those who can most make a difference at national, regional and local levels of planning for biodiversity.

A number of sociological (e.g. landowner/community recruitment) and technical (e.g. definition of ecosystems) challenges to implementing more effective and sustainable biodiversity conservation are overcome by application of landscape ecology principles. None of these, however, may overcome the shortcomings of leadership in implementing and funding this new approach. Unless… the visual representation or map of a bioregional plan based on landscape ecology can capture the imagination of politicians and other leaders it could provide the necessary impetus to progress this important approach to protecting habitat and biodiversity.

Meanwhile, there is a continuing loss and fragmentation of New Zealand's remaining indigenous cover and habitat with the consequential loss of indigenous biodiversity. This ongoing loss, coupled with the looming impact of climate changes, make the need for a strategic approach to biodiversity conservation and the protection of functional landscape patterns even more imperative.

CHAPTER FOUR – THE NEW 'LEEP' MODEL

4.1 INTRODUCTION

Chapter Four proposes an alternative model for biodiversity conservation planning. This model is based on the foundations of the principles and elements of landscape ecology and the English planning model extensively defined in the **Chapter Two** Literature Review. The aim in developing an alternative model is to complement and build on the historical gains of traditional conservation methods, namely species recovery, offshore island sanctuaries, and pest management programmes that have served New Zealand conservation well and have made New Zealand an international leader in the application of these methods. The previous programmes, while protecting species in often discrete locations, have only 'bought us time', and have not been sufficient on their own to halt the loss and fragmentation of indigenous cover and the loss of New Zealand biodiversity recognised in the NZBS (See **Chapter One**).

The literature review and interviews with key experts, strongly suggests a new more strategic approach is required for sustainable and effective biodiversity conservation. The model proposed in this Chapter, and applied in subsequent chapters, has potential to overcome many of the current barriers (listed in **Chapter One**) to implementation of a more ecosystem-based approach to conservation and ecological restoration.

4.2 THE 'LEEP MODEL'

This model integrates two other approaches or models – principles from the emergent discipline of landscape ecology, and the new English biodiversity conservation policy framework. This approach is called the **'LEEP'** Model of strategic biodiversity conservation planning. LEEP is an acronym taken from **LE** (**L**andscape **E**cology) and **EP** (**E**nglish **P**lanning). Together they demonstrate an effective integrative and comprehensive approach to biodiversity conservation planning that could provide increased traction towards more effective progress in strategic conservation planning in New Zealand at national, regional and local levels, and to integrate planning for biodiversity resources on public and private land. Together they also represent a 'leap', or "paradigm shift" (Poiani & Richter, 1999), from current mainstream conservation thinking and practice. This proposed integrated model is illustrated in **Diagram 9.**

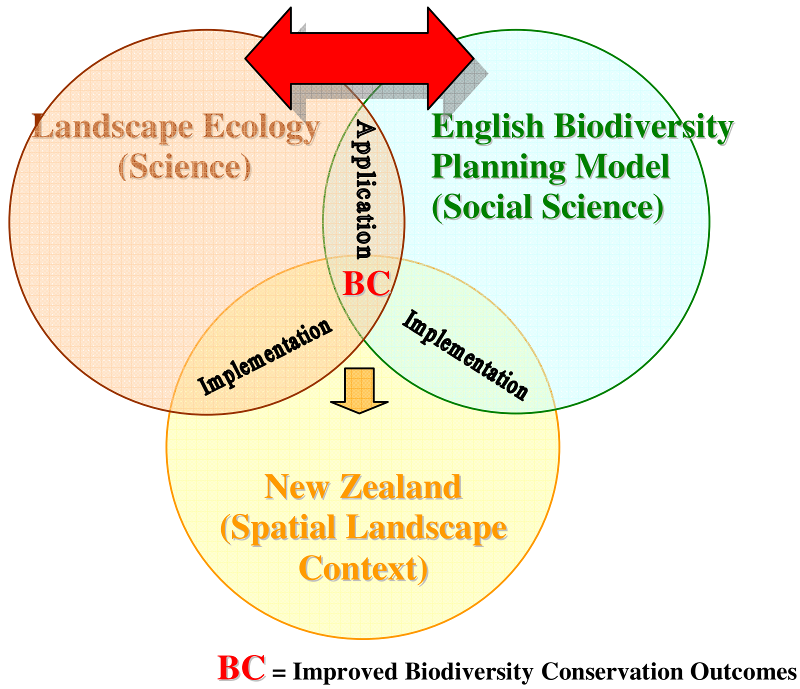


Diagram 9. The LEEP Model for Strategic Biodiversity Conservation Planning in the New Zealand Context. Effective and sustainable biodiversity conservation largely occurs at the intersection of the three domains (BC).

In more fundamental terms this model also represents an integration of two more foundational, and traditionally discrete, approaches to biodiversity conservation planning - one, the purely scientific approach and the other, a land-use planning or social science approach that are indicated in parenthesis in **Diagram 9**. An explanation of the two main elements of the LEEP Model - landscape ecology and English planning - form the basis of the rest of this chapter.

One of the advantageous dynamics of this model is that the greater the area of overlap or integration of the three elements the more sustainable and effectively the conservation objectives are achieved – the 'BC' intersection (**Diagram 9**) is enlarged. The science of landscape ecology needs to be complemented by the understanding and processes of social science. And both need to engage more fully and in increasing detail with the New Zealand context to translate strategic objectives into implementation on the ground.

4.3 COMPARISONS – FUNDAMENTAL ELEMENTS AND 'PHILOSOPHIES'

A comparison of the elements of both these models shows they are complementary, rather than mutually exclusive. **Table 16** provides a comparison of the fundamental elements and overlying 'philosophies' associated with each model. English biodiversity planning is a somewhat natural extension or implementation vehicle for landscape ecology into landscape-scale land-use planning. While landscape ecology forms the fundamental basis for the development of policy and spatial plans for English biodiversity conservation.

Table 16. Comparison of Landscape Ecology and English Biodiversity Planning Models

Landscape Ecology	**English Biodiversity Conservation Planning**
• A scientifically-based, large-scale, bioregional approach to ecological planning • Seeks sustainable ecological, social, and economic outcomes • Encompasses both conservation and 'productive' land • It includes human activity as part of the ecosystem and seeks to integrate • Respects private property rights • Recognises intrinsic value and ecosystem services provided by existing and enhanced conservation outcomes • Seeks win/win outcomes for both conservation and production. • Is both top-down and bottom-up derived providing top-down ecological guidance while acknowledging local bottom-up experience. Recognising long-term sustainable solutions must involve involvement, understanding and recruitment of local communities • Provides a 'tool box' of design rules for protecting, enhancing and restoring functional landscapes	• A 'real-life' spatial planning model to guide development of strategic biodiversity conservation plans and policies and associated activity. • Premised on requirement to build sustainable communities • Concerned with sustainable socio-political processes as well as sustainable outcomes • Mandatory, top-down driven in the sense it is lead by multi-sectoral partnerships at central, regional and local government level • Bottom-up recruitment of local partnerships are essential to implementation • Explicit requirement to look at opportunity for habitat enhancement and eco-restoration • Facilitate wide public access to species and habitat databases • Clear guidelines on general method of implementation • Requirement to address and plan for impacts of climate change on biodiversity • Based on broad principles of landscape ecology

Sources: (Landscape ecology - A. F. Bennett, 2003; Forman, 1995; Forman & Godron, 1986; Noss & Cooperrider, 1994; Soule & Terborgh, 1999) (English Planning - Catchpole, 2006; ODPM, 2004c; ODPM, 2005c, 2005d; ODPM et al., 2006; G. Saunders & Parfitt, 2005)

A number of authors also highlight important concepts that are instrumental to understanding the ecological significance of the landscape ecology approach to biodiversity conservation compared with traditional species or patch (place) conservation. These are summarised in **Table 17.**

Table 17. Values Underpinning the Significance of Landscape Ecology for Biodiversity Conservation

Value
1. Protecting ecosystems and their natural processes protects the species within the ecosystem
2. Human activity and modified landscapes are part of the ecosystem and are integrated and managed as part of the ecological landscape
3. The spatial pattern of remnant vegetation and other landscape elements influences biodiversity
4. Functional ecosystems, rather than simply physical systems (which may or may not be related) are the key to healthy and sustainable landscapes
5. Ecosystem, region or landscape is the fundamental unit of effective and sustainable conservation
6. Every part of the landscape is important for biodiversity conservation

(**Source**: A. F. Bennett, 2003; Bissonette & Storch, 2003; Crooks & Sanjayan, 2006a; Forman, 1995; Forman & Godron, 1986; Noss, 1983, 1996; Park, 1998, 2000)

Some of the implications of these values are that landscape ecology shifts conservation focus from species and reserves to the balance between core reserves, multiple-use buffers and the developed/ modified matrix (Park, 2000:30). Landscape ecology is more concerned with ecological processes than 'place' (Park, 2000:30). Consistent with point 4 above, Park (2000:44) notes that there is a high level of consensus among New Zealand ecologists that biodiversity conservation should be 'ecosystem-based'. Park (2000:30) also identifies another defining characteristic of an landscape ecology approach to conservation is co-operation and co-ordination (partnership) between conservation managers, community, landowners and other stakeholders and information holders which is consistent with the English model.

4.4 LANDSCAPE ECOLOGY – SPATIAL COMPONENTS

The foundational 'infrastructure' of a biodiversity conservation strategy based on a landscape ecology approach comprises a system of four fundamental spatial building blocks listed and characterised in **Table 18,** which is partially derived from **Table 6** in **Chapter 2**.

The natural development of these 'core-buffer-corridor-matrix' elements is the protection or development of ecological networks at local, regional, national and even transnational level, examples of which were given in **Section 2.2.4** (**Figures 6** and **7**).

Table 18: Four Basic Ecological Landscape Elements

Element	Characteristics & management
1. Core remnants	• The 'backbone' of any regional biodiversity plan • Without strictly protected areas representing most of a region's biodiversity, biodiversity loses are unavoidable • 10-20% indigenous vegetation cover threshold is a critical factor necessary for sustaining native fauna – big or small - regardless of configuration • Critical that core indigenous remnants are maintained in as close as possible their natural state
2. Buffer zones	• Recognise that a system of core reserves is not sufficient to maintain biodiversity • Recognise that ecosystems extend beyond conservation reserves and boundary or edge effects caused by adjacent land uses or ecosystems can affect the quality of core areas and corridors • Transitional multiple-use buffer zones can protect and compliment core areas and act as a way to integrate development and conservation • Each buffer zone is managed with native biodiversity as a priority while allowing for a greater range of human use than core reserves • Buffers provide for less intense use than in the general landscape and sympathetic complimentary eco-restoration that shields core areas from harmful activities, reduces environmental gradients and extends the functional ecosystem out from the original core
3. Eco-linkages	• Connectivity is a fundamental concept in landscape ecology and fundamental to any effective strategic landscape-scale biodiversity conservation plan. • Act as movement corridors (daily, seasonal & migratory, dispersal, and range extension, climate change adaptation), habitat & refuge, and buffers in otherwise disturbed ad hostile landscapes • Species persistence is enhanced by the amount and quality (content and width) of 'corridors', stepping stone remnants and habitat mosaics • Develop ways to preserve existing connections and restore severed connections • Corridors can include riparian strips, shelterbelts, transport corridors, forest corridors or mosaics
4. Matrix	• Forms the background of heavily modified ecological systems to other three elements • Can be forested, cultivated or suburban, but can also provide opportunities for ecological enhancement and restoration that can also benefit production objectives

(**Source**: A. F. Bennett, 2003; Crooks & Sanjayan, 2006a; Forman, 1995; Forman & Godron, 1986; Noss & Cooperrider, 1994; Radford et al., 2004)

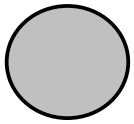
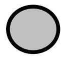
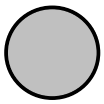
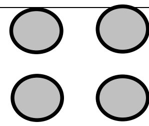
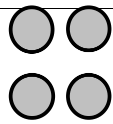
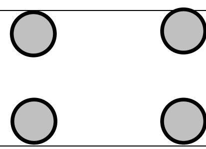
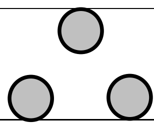
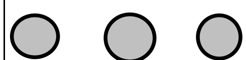
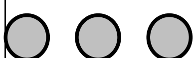
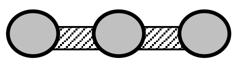
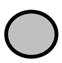
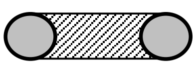
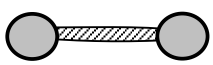
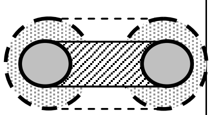
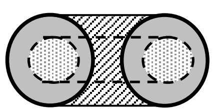
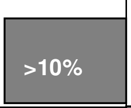
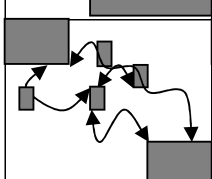
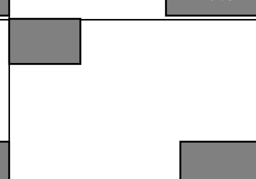
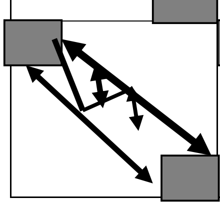
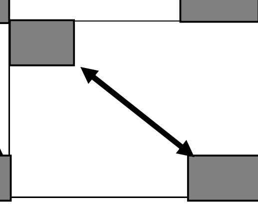
4.5 LANDSCAPE DESIGN RULES

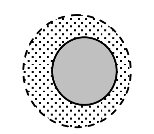
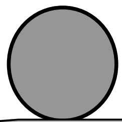
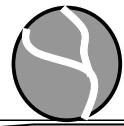
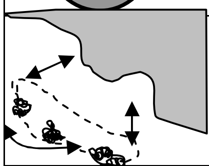
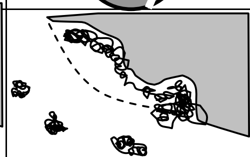
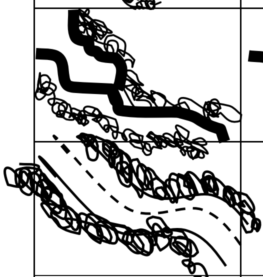
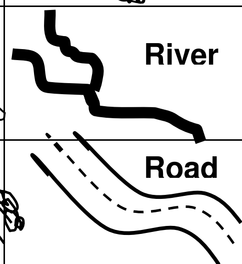
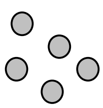
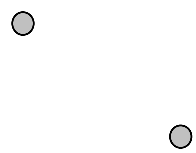
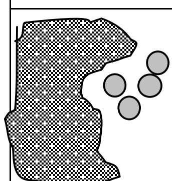
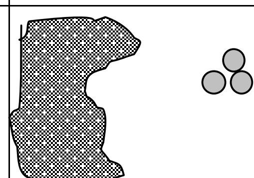
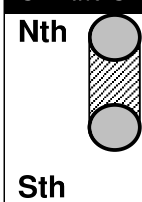
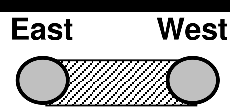
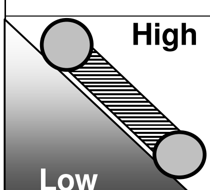
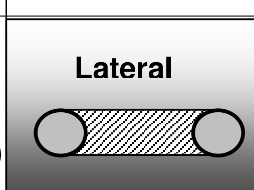
While the critical elements and philosophies behind landscape ecology are complimentary and compatible to those of the English biodiversity conservation model, the practical elements for the LEEP model are a broad set of ‘rules’ that form the explicit or implicit background to any landscape ecology approach to large scale biodiversity planning. The original ‘rules’, described in **Section 2.2.2** began with the island biogeographic theory work of MacArthur and Wilson (1963; MacArthur & Wilson, 1967) which was then adapted by Diamond (1975; Diamond & May, 1976) and applied to terrestrial habitat ‘islands’ situated in modified landscapes. A number of additional ‘rules’ have been added since.

A list of practical ecological rules has been collated from the literature on landscape ecology and summarised as **Table 19**. These rules are used in an application of the LEEP model to guide maintenance or development of functional landscapes where natural processes are retained or enhanced. These rules are generally accepted as a best approximation of the guiding principles governing effective design of spatial-based landscape elements and also form the basis for policy development and implementation.

Forman (Pers.comm. 2006) was comfortable with this new summary of basic principles of landscape ecology (see interview **Appendix B**) as a development of Diamond (Diamond & May, 1976). He cautioned, however, that these rules represent an ‘ideal’ world that we don’t live in. So while the diagrams are useful generalisations they are also ‘academic’, particularly the climate change north/south alignment of reserve networks where achieving this may be a luxury or not at all possible. Forman provided some additional ‘rules’ about the development of stepping stone patches that have been incorporated as rules 12, 16 and 17 in **Table 19.**

Table 19. Design Rules for Functional Ecological Landscapes

Better	**Worse**	**Original Rules**
After Diamond (1975)		[From *Conservation Strategy* (IUCN, 1980)]
		1. Large reserves are better than small reserves.
		2. A single large reserve is better than a group of small ones of equivalent total area.
		3. Reserves close together are better than reserves far apart.
		4. Reserves clustered compactly are better than reserves in a line.
		5. Reserves connected by corridors are better than unconnected reserves.
		6. Round reserves are better than long, thin ones.
Better	**Worse**	**Additional rules derived from various authors**
		7. Wide corridors are better than narrow ones.
		8. Buffers on the outside of the core and corridor are better than having them inside.
		9. Vegetation coverage greater than 10% is better than less than 10% – or other critical threshold relative to the particular ecosystem.
		10. Stepping stone patches are better than no proximate connection.
		11. Redundancy - having alternative routes is better than only one route.

<table>
<tr><th>Better</th><th>Worse</th><th>Additional rules derived from various authors (Cont’d)</th></tr>
<tr><td></td><td></td><td>12. Prefer enlarging patches before developing corridors.</td></tr>
<tr><td></td><td></td><td>13. In an indigenous core area, <u>no</u> roads or tracks is better.</td></tr>
<tr><td></td><td></td><td>14. It may be more ecologically important to protect and enhance solitary scattered treess or small remnant patches than to enlarge an already large remnant core.</td></tr>
<tr><td></td><td>
</td><td>15. In a developed matrix, vegetated riparian and road corridor strips are better than none.</td></tr>
<tr><td></td><td></td><td>16. Clusters of stepping stone patches are better than single isolated ones or ‘rows’ of patches.</td></tr>
<tr><td></td><td></td><td>17. Patch development adjacent to existing patches or large old trees is better than patch development in isolation.</td></tr>
<tr><th colspan="3">Climate Change</th></tr>
<tr><td>
</td><td>
</td><td>18. North/south orientation allowing for more habitat space adjustment is better than a simple east/west orientation.</td></tr>
<tr><td>
</td><td>
</td><td>19. Orientation spanning altitude change is better than same altitude.</td></tr>
</table>

4.6 ENGLISH PLANNING - MAPS AND GOOD PRACTICE PRINCIPLES

The "Good Practice Principles" for the development of strategic biodiversity conservation maps – 'opportunity maps' discussed and illustrated in **Chapter Two** - provide a framework for use in the proposed integrated LEEP model. These principles guide the conservation planning process, methodology and communication and are set out in **Table 20. (**Note**:** A more detailed checklist is reproduced in **Appendix H**).

Table 20. Good Practice Principles for Strategic Biodiversity Conservation Maps

Elements	Requirements
PROCESS	Links from and to national, regional and local priorities
	Strong partnerships from the outset
	On-going partnerships
	Continuity across boundaries and scales
	Dialogue with local expertise
	Links to other sectors
METHODOLOGY	Use the best data available
	Complexity in keeping with purpose
	Use an ecological rationale
	Use a landscape framework
COMMUNICATION	Design the map to suit its purpose
	Understandable the look at
	Careful wording to accompany the map
	Use right media to communicate the map

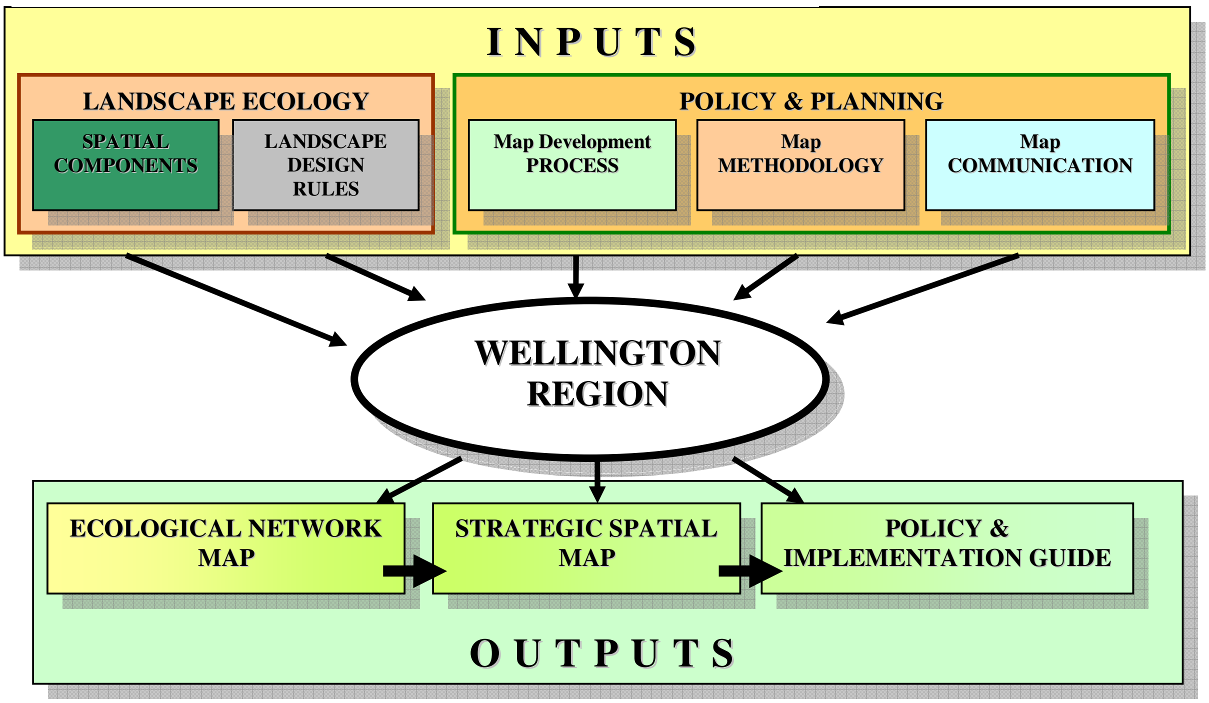
(**Source**: G. Saunders & Parfitt, 2005:57)

Decisions about each of these will need to be made to identify the requirements and approach for any given location and situation. Development of the strategic map(s) is accompanied by the development of policy and implementation guidance for each of the conservation areas identified on their maps – as presented in the English case studies of opportunity maps (**Section 2.3.5** - particularly **Case Study 2**).

4.7 MODEL FLOW CHART

The problem definition (**Section 1.2**) and literature review of the New Zealand context (**Chapter 3**) suggests that basic high-level, strategic maps for biodiversity conservation with protection, management and restoration guidelines are a major omission from current planning processes and documents. The inputs and outputs for the LEEP Model and this integration of elements of the landscape ecology and biodiversity conservation planning are shown in flow **Diagram 10**.

Diagram 10. Flow Chart of Inputs and Outputs of the LEEP Model.



The strategic or high-level products from applying the LEEP Model are:

1. **Ecological network map** – a large-scale (regional) map identifying existing and potential functional relationships between core remnants that will guide the development of the strategic spatial map.
2. **Strategic spatial map** – a large-scale spatial map identifying and delineating areas or zones of existing or potential core, buffers, eco-linkages and matrix for suitable protection and enhancement of ecosystem function, while recognising the existence and need for development and human activities.
3. **Policy and implementation guide** – provides a set of policy objectives and implementation options for each zone identified in the strategic spatial map.

4.8 USES OF MAPS AND IMPLEMENTATION GUIDE

These maps can serve any or all of several potential environmental planning functions shown in **Table 21**.

Table 21: Potential Uses of the Strategic Biodiversity Map

Theme	Action
Restoration & protection	• Form basis for defragmenting landscapes & restoring functional landscape & ecosystem processes • Priority habitat protection & restoration • Promote acceptance & use of a greater suite of conservation & restoration tools
Integration	• Integrate conservation focus covering: – public & private land – conservation, rural & urban areas – conservation, restoration & development activities – sectoral, community, landowner & environmental agency interests • Integrate environmental services & benefits provided by protected & restored indigenous areas
Guidance & prioritisation	• Identification of recommended areas for protection (RAPs) • Prioritise: – species recovery & pest management programmes – protection, land purchase or covenanting activities and funding – conservation & biodiversity research activities and locations • Guide: – location & design of urban expansion – resource developments such as wind farms to ensure avifauna flight corridors are protected – boundary issues & inter-regional consistency – detailed district & sub-regional conservation planning – environmental education programs – transport & utility corridor verge restoration & management – protection & restoration of environmental services provided by remnant & restored areas. – forestry cutting, planting, roading & management
Facilitation	• Envisioning & recruitment • Adaptation to climate change impacts • 'Paradigm shift' from conventional thinking & traditional conservation methods • Brainstorming & comparison of strategic options • Detailed desktop & on-ground work
Sequestration projects & carbon credits	• Identify planting projects for carbon sequestration programmes • Provide basis for identifying & marketing carbon credit opportunities & 'corporate' carbon footprint reduction • Provide a funding source for integrated planting & eco-restoration programmes

Broadly, these functions cover identifying priority or special areas; establishing priority activities, resource allocation and research; the integration of planning for traditionally separated or conflicting land uses; and facilitating future actions, including promoting brainstorming non-traditional ideas about existing and possible future biodiversity conservation opportunities and activities. This range of strategic uses also has potential to create more conservation and development efficiencies and synergies and promote more effective and sustainable outcomes. In New Zealand, application of the strategic map and policy implementation guide could be accomplished through a range of critical planning documents that may include the following:

- **National Policy Statement (NPS) on Biodiversity** under RMA 1991 Part 5, sections 45 -55. An NPS could be revisited by MfE and DOC with the potential of applying the kind of strategic spatial and integrating approach described by the LEEP Model to guide and set national biodiversity objectives and provide additional guidance to regional and territorial authorities who must give effect to NPS under Sections 62(3) and s75(3)(a), respectively, of the RMA. Failing this a Statement of National Priorities for Biodiversity Conservation could be developed to complement or 'replace' the one announced in 2007 (See **Section 1.2.2**).

- **DOC 'Strategic Direction'.** The Departmental 'Direction' could be reviewed and refined by DOC Head Office to consider the advantages of applying the LEEP Model at the national level and across all Conservancy, and resourcing the development of maps for all Conservancy to guide CMS reviews and set conservation priorities.

- **Conservation Management Strategy** (CMS) of DOC under the Conservation Act 1987 Part 3, sections 17D and 17 F. The LEEP Model could be used to guide Conservancy CMS and in identifying priorities for species management, pest management, land purchase and research. Advocacy priorities could also be identified for developing appropriate provisions in Regional Planning Strategy and district planning schemes.

- **Regional Policy Statement** (RPS). Under RMA 1991 sections 6(c) and 7(d) regional councils have responsibilities for the protection of significant indigenous vegetation, habitats and ecosystems. Regional council could review their RPS, Regional Biodiversity Plans and Regional Pest Management Plans to reflect priorities and opportunities identified by strategic maps. Under RMA sections 61(2)(a)(i) and 62(3) councils are also required to give affect to any CMS or NPS, respectively. Appropriate provisions in RPS would guide the development of regional biodiversity plan, and provide strategic guidance for the biodiversity conservation provisions of constituent local authorities and individual farm plans undertaken by the regional council.

- **District Plans.** Territorial authorities are also subject to the requirements of RMA 1991 sections 6(c) and 7(d) to protect "significant" indigenous vegetation, habitat and ecosystems and reflect the provisions of CMS, NPS and RPS (RMA s.74(2)(b)(i) and s75(3)(a) and (c)). The existence of regional strategic biodiversity maps may add to the 'significance' of any 'local' indigenous vegetation and habitat, and their part in any larger national, regional, or sub-regional ecosystem. This additional status may influence the level of protection and restoration afforded to biodiversity within district planning schemes and subdivision controls. This could provide a more coherent and consistent approach to biodiversity planning within districts than generally occur now (See **Section 1.2.1**).

- **National Biosecurity Strategy** of Biosecurity New Zealand, **Animal Health Board** and **National Pest Management Strategy for Bovine Tb** could recognise and reflect priorities identified by strategic biodiversity maps and be integrated with the plans and strategies of local authorities and DOC to better facilitate control of animal and plant pests and the protection of indigenous biodiversity from invasive species.

- **Queen Elizabeth II National Trust Policy.** Strategic Maps would assist the Trust in establishing priority areas and criteria for land covenants over indigenous remnants on private land.

- **Landcorp Management Plans.** Landcorp is a major land manager throughout New Zealand. The protection of strategically significant indigenous forest identified by strategic biodiversity plans could be reflected in Landcorp land management plans.

- **Advocacy plans and policies of environmental NGO's.** Strategic biodiversity maps could guide the priorities of NGOs such as the New Zealand Royal Forest and Bird Protection Society and the New Zealand Fish and Game Council and either complement or provide greater integration with the activities of government conservation and environmental agencies.

- **Farm Plans.** Water and soil conservation plans of private land owners could better reflect the strategic role that privately owned indigenous forest remnants play in regional as well as local ecosystem dynamics and biodiversity conservation. Strategic biodiversity maps could be used to explain, educate, and recruit private property owners to take action or join programmes to protect remnant forest/bush through providing a strategic context for the significance of such protective measures.

- **Activities of Landcare and Streamcare Groups.** Strategic Maps can be used to identify strategic locations for community volunteer protection and restoration activities and recruit additional support and funding for such activities.

These agencies and organisations together could also form the basis of a biodiversity partnership and forum to develop the details and veracity the strategic biodiversity plan, the integration of the plan into planning documents, and to oversee and coordinate implementation of the plan.

4.9 SUMMARY

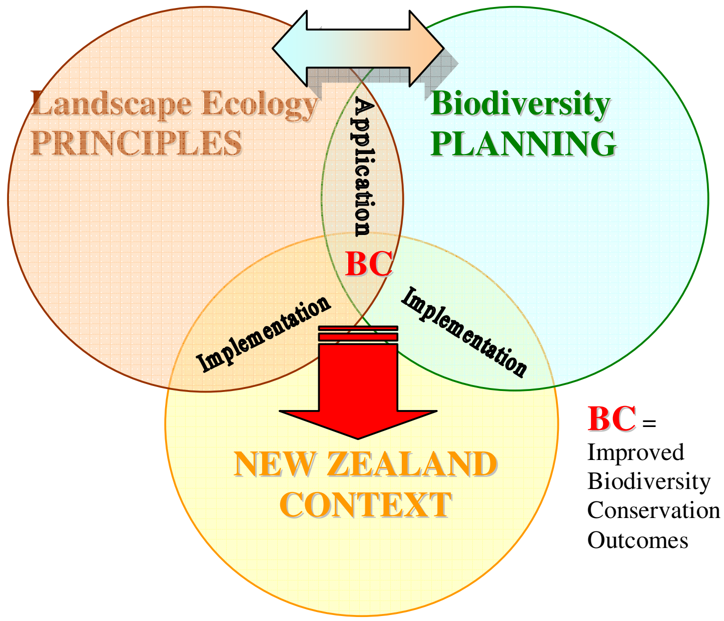
The new LEEP Model for strategic biodiversity conservation planning (**Diagram 9**) enables the preparation of a landscape-scale strategic spatial map and accompanying management policy guidance for map areas. A set of ecological design rules (**Table 19**) provides a flexible 'toolbox' for designing functional landscapes, while opportunity mapping provides a suite of iterative map development processes, methodologies and communication approaches (**Table 20**) that can be adapted for different purposes, data availability and target audiences. Together, these elements form the theoretical basis for the LEEP Model. These elements will now be applied to an actual New Zealand context in the following **Chapter Five**.

CHAPTER FIVE – APPLICATION – WELLINGTON CASE STUDY

5.1 INTRODUCTION

Chapter Four described a new model for strategic biodiversity conservation planning to slow the on going loss of natural habitats, biodiversity and ecological processes (see **Chapter One**). **Chapter Five** now seeks to make the next step and apply the LEEP Model (**Diagram 11**) to the New Zealand context through use of a Case Study – the Wellington Region.

Diagram 11. Application of the LEEP Model to a New Zealand Context.



5.2 THE WELLINGTON REGIONAL CONTEXT

The Greater Wellington region (delineated by the Greater Wellington Regional Council boundary) was chosen for the first application of the LEEP Model for a number of reasons:

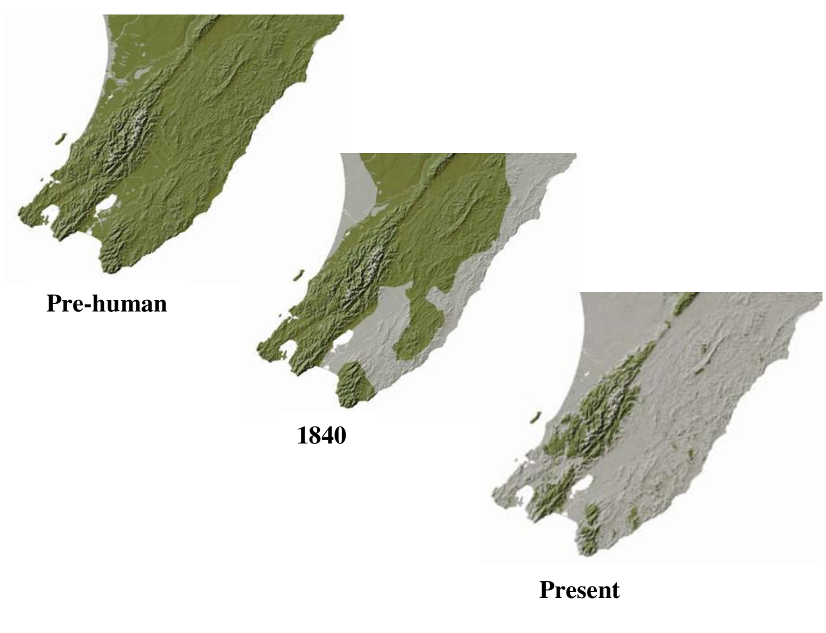
1. It is a discrete and clearly identifiable geographic area;
2. It provides a landscape scale that is useful to demonstrate the application of the LEEP model and address the identified current gap in strategic biodiversity planning in New Zealand;
3. It contains a 'typical' New Zealand assemblage of public and private land, natural and modified landscapes, urban, rural and conservation lands that typifies the tensions between conservation and development throughout New Zealand;
4. It is representative of the historical modification caused by human settlement and the resultant destruction and fragmentation of indigenous cover and ecological

degradation common to most regions of New Zealand. The Wellington Region is also not part of the Protected Natural Area Programme and has very few areas specified by DOC as “RAPs” – recommended areas for protection (Pers.comm. Ogle 2007);

5. It is a convenient area to study for the author who lives in Wellington and because various technical, expertise and publication resources were therefore readily available.
6. The data sets and maps for the Wellington Region were readily available from the Greater Wellington Regional Council who assisted with the base map development and output.

Figure 12 illustrates the fact that the Wellington Region was once extensively forested, and has experienced significant loss of indigenous forest cover following human settlement. With forest loss there is an implied dramatic loss of biodiversity. Remaining forest cover is highly fragmented and contains many isolated remnants, some too small to be visible on the large-scale images of **Figure 12**. The bulk of remnant forest is mostly restricted to the steep axial Rimutaka and Tararua ranges, much of it protected, and these protected forested ranges will form the core areas around which strategic conservation planning may occur. Large areas of the region, particularly Wairarapa, have very few remnants of any spatial significance. However, application of the LEEP model provides an opportunity to guide protection and restoration priorities and improve sustainable and effective protection and enhancement of the region’s biodiversity resources.

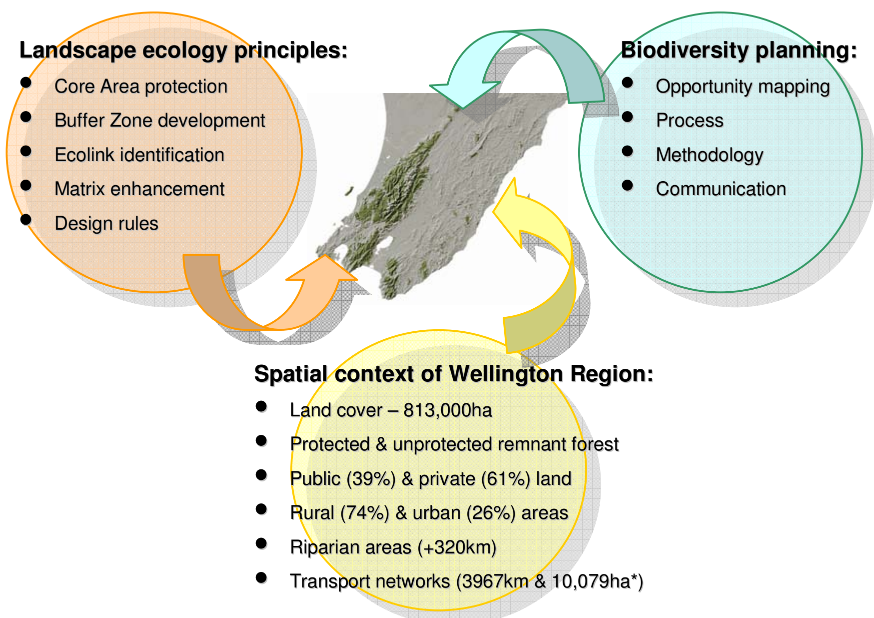
Figure 12: Indigenous Vegetation Loss in the Wellington Region. An almost 80% reduction in cover since human settlement. (Used with permission Roger Smith, Geographx NZ Ltd)



5.3 APPLICATION OF THE 'LEEP' MODEL – SEVEN STEPS

Historically, indigenous species existed and evolved in the Wellington context within a landscape marked by a high degree of connectivity. The aim of this strategic planning process is not to 'turn back the clock' and return the Region to some previous, presumably 'healthier', ecological state. Rather, the intention is to better protect and enhance what currently exists and progressively create a better integrated, more ecologically functional and more sustainable regional ecosystem that will provide for the stability and persistence of indigenous species and habitat. In this way, planners and conservation managers increase the possibility of arresting the decline in biodiversity, not just in the Wellington Region, but by application of the same process to neighbouring regions, to halt the decline nationwide.

Diagram 12. Inputs to a Strategic Biodiversity Conservation Map for the Wellington Region



Statistics source: Greater Wellington Regional Council
* Total road length and road reserve outside metropolitan areas

Diagram 12 illustrates the inputs to the process of developing strategic biodiversity map resources for the target Wellington Region and identifies several characteristics of the spatial context of the Wellington Region. These include:

- **Land cover**. This information is derived from the most recent Land Cover Database (LCDB2) and provides a snapshot of the distribution of exotic and native vegetation that forms the basis for identifying existing and potential biodiversity resources in the Wellington Region.

- **Natural and modified landscapes**. Both these landscapes contain greater or lesser degrees of indigenous biodiversity resources that need to be protected and enhanced and each has an important role in supporting and integrated and ecologically functional landscape.
- **Public and private land**. 39% of the Wellington Region is in public ownership. Most public land has protected status. In the Wellington Region, much of the public land forms the large core areas that provide the 'backbone' for biodiversity protection and enhancement. Significant amounts of indigenous remnants occur on private land, much of this strategically important, and most of it unprotected. Privately-owned native forest (and other native cover such as duneland and wetland) has the potential to provide some of the most important biodiversity gains (or losses) depending on formally or informally securing their long-term protection.
- **Rural and urban areas**. Biodiversity resources exist in both these modified landscapes. Appropriate management regimes, education programmes, and volunteer and landowner 'recruitment' can achieve better protection and enhancement of biodiversity resources. Roadside reserves, shelterbelts and hedgerows have particular potential in rural areas as conservation corridors.
- **Riparian areas**. Over 320km of riparian corridors are a significant existing natural network. When appropriately vegetated and protected, riparian areas make a major contribution towards connecting landscape elements, promoting ecosystem function and health, as well as protecting freshwater habitats.
- **Transport networks**. Transport corridors (road and rail) are an existing and future man-made network whose significant verge areas provide potential for planting programmes to strategically connect large core areas and small remnant patches. The potential of appropriately planted roadside strips as conservation corridors has yet to be recognised in New Zealand.

The step-by-step development of strategic biodiversity maps follows the flow diagram of inputs and production of the three outputs (Ecological network map, strategic spatial map and a policy and implementation guide) shown in **Diagram 10, Chapter 4**.

STEP1: DETERMINE TARGET AREA

Generally the target region will also determine the scale of the maps to be developed and the ecosystem and processes to be considered. Cross-boundary issues with areas outside the target area will need to also be recognised and considered. Developing a functional landscape or ecosystem requires a large-scale approach. This is best achieved by using a regional, possibly a national scale, to produce strategic maps that can be either joined to other regional maps to form inter-regional or national maps, or form the basis for strategic biodiversity maps for sub-regions, districts or catchments.

STEP 2: CHOOSE PURPOSE AND TARGET AUDIENCE

The purpose of this case study is to demonstrate the potential of basic high-level strategic biodiversity conservation maps with a view to recruiting support for such an approach from a range of policy developers and resource managers and further development and implementation of this model.

Large-scale or regional biodiversity maps provide a 'handle' for politicians, officials, the general public and private landowners to gain a readily understandable overview of the biodiversity resources, ecosystem function and dynamics of a region. Strategic maps will provide an opportunity for politicians and officials to take a more sustainable, defensible and long-term approach to resource management in their region. Strategic maps will assist placing more localised activities and properties in perspective with their larger surroundings and ecosystem dynamics. This will also provide an opportunity to educate and recruit support for strategic conservation policies and their implementation within the region.

Strategic biodiversity maps provide an opportunity for DOC and the Greater Wellington Regional Council to take a more holistic, integrated and participatory approach to biodiversity planning within and between regions. It provides these agencies an opportunity to 'ask different questions' and move away from traditional species and isolated 'place' conservation programmes. For DOC such maps will serve to highlight ecosystem dynamics that transcend the public conservation estate and the significance of biodiversity resources on private land. Both DOC and Greater Wellington Regional Council would be key to 'ground-truthing' and validating the strategic biodiversity maps and could use them as a basis for identifying areas for more detailed work.

The ecological network, strategic spatial plan and policy and implementation guide would have added significance for the constituent territorial authorities – Wellington City, Porirua City, Kapiti Coast, Hutt City, Upper Hutt City, and combined Masterton, Carterton and South

Wairarapa district council. The maps would help put each district into a broader ecological context and its own unique significance within that context. Indigenous remnants once thought ‘insignificant’ may find new importance as critical corridors or stepping stone patches. Planned development may now be appreciated as having potential impacts on ecosystem dynamics previously not identified and new development controls put in place. The policy and implementation guide (**Table 14**, **Section 2.3.5**), along with the landscape design rules (see **Table 19, section 4.5**), provide a range of ecological and ‘social’ tools for implementing effective and sustainable protection or restoration of biodiversity resources. Ideally, the territorial authorities would want a smaller scales map of their own districts encompassing the regional spatial strategy, but delineating strategic biodiversity in more detail at the district level. The LEEP Model is adaptable and can be easily applied to the smaller scale.

This broad-brush approach towards developing a strategic spatial biodiversity conservation map has several advantages:

- **It is simple** to construct and the methodology is easily transferable to other regions (including countries and continents) and to larger (NZ-wide) or smaller (district) areas
- **It is conceptual** rather than focusing on the technical detail of developing a more precise map – this can be done later with further expertise from community, landowners, sectoral interests and conservation scientists.
- **It is visionary** providing a profound, strategic overview of the dynamics of existing and potential ecosystem dynamics within a region and of the biodiversity relationships between constituent areas, catchments and districts.
- **It is envisioning** providing a ‘big-picture’ overview for landowners, communities and district councils to better comprehend and shape their contribution to local, regional and even national biodiversity conservation outcomes.
- **It is adaptable** allowing either further conceptual development at the large-scale or provides a basis for ‘ground-truthing’ and more detailed mapping.

These advantages make such a strategic approach an attractive tool for facilitating better biodiversity conservation outcomes.

STEP 3: CHOSE PRIMARY DATABASE MAP

In the LEEP model, land cover is used as a fundamental indicator of habitat suitability and landscape functionality. The most recent Land Cover Data Base (LCDB2) provides a map of existing cover. Classes of land cover were merged and simplified to provide a broad and more useful indication of fundamental landscape elements. Seven land cover classes were established for the Wellington region as listed in **Table 22**.

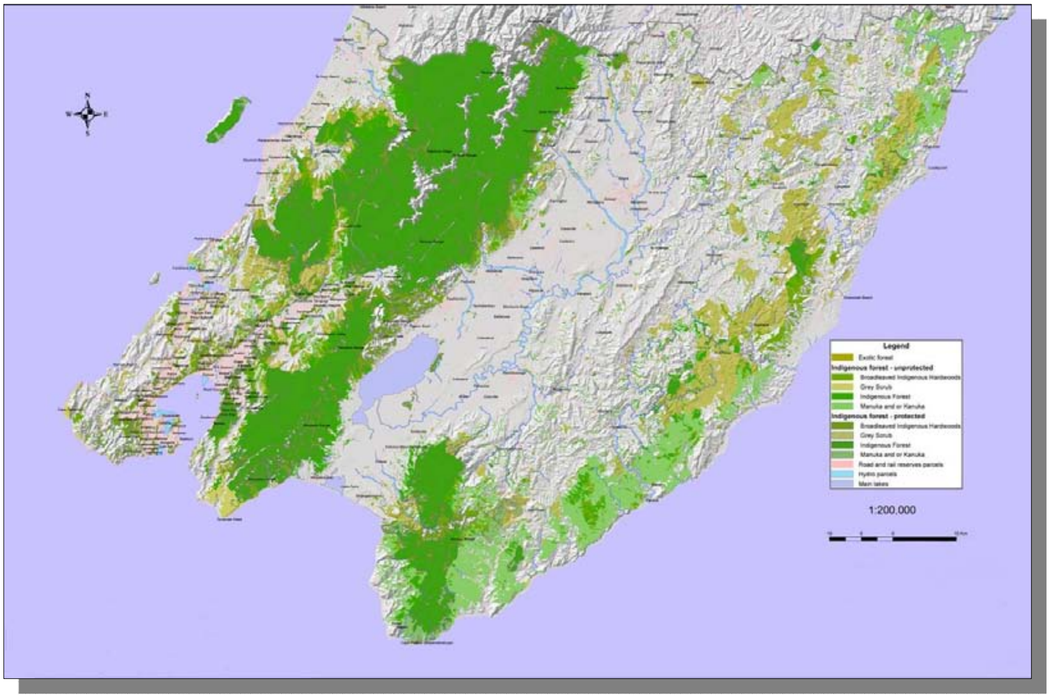
Table 22: Land Use Classes for Base Map

Class	Characteristics & ecological value
Indigenous forest	Remnant forest – large and small, protected and unprotected. Core areas and fundamental building blocks of a functional ecological landscape
Exotic forest	Reduced biodiversity but still provide valuable habitat. Can act as buffer and corridor
Grey scrub (e.g. kanuka/manuka)	Reduced biodiversity but provide valuable habitat, buffer, corridor and eco-restoration potential
Farmland	Minimal habitat value. Potential to contribute to ecological enhancement
Main lakes & rivers	Valuable riparian habitat and act as strategic natural corridor network
Road reserve	Low habitat value, but potential to contribute to enhanced corridor network
Main urban areas	Mixed habitat value, but potential for urban eco-restoration

The base map using these land use classes is shown in **Figure 13** (see also enlarged map **Appendix J**).

While these classes may form the standard basis for mapping other areas, the number of classes can be expanded to recognise significant other land cover (vegetation) types such as wetlands, dunelands and alpine areas.

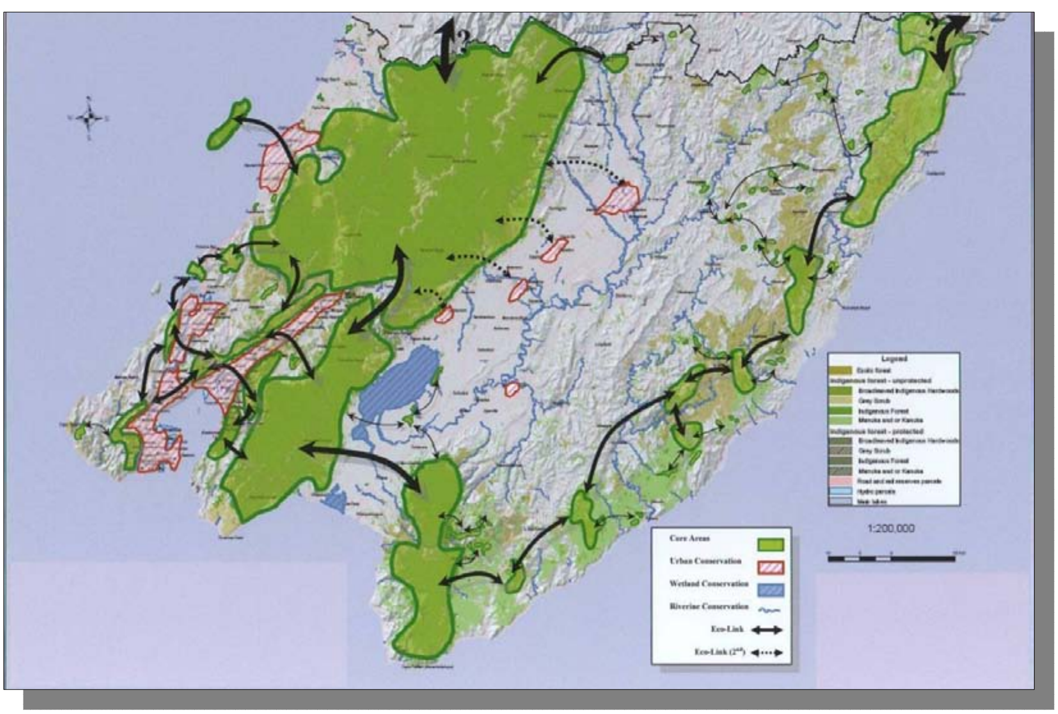
Figure 13. Base Land Cover Map of Wellington Region (See **Appendix J** enlargement)



STEP 4: IDENTIFY EXISTING AND POTENTIAL ECOLOGICAL NETWORKS

Major masses and patches of indigenous forest remnants were delineated on the land cover base map (from Step3). These form the likely core areas of biodiversity. Real or potential eco-links between these core areas were then identified. These define a rudimentary 'regional ecological network' as shown in the map **Figure 14** (see also enlarged map **Appendix K**).

Figure 14. Regional Ecological Network for Wellington (See **Appendix K** enlargement)



STEP 5: DELINEATE FUTURE ECOLOGICAL MANAGEMENT ZONES

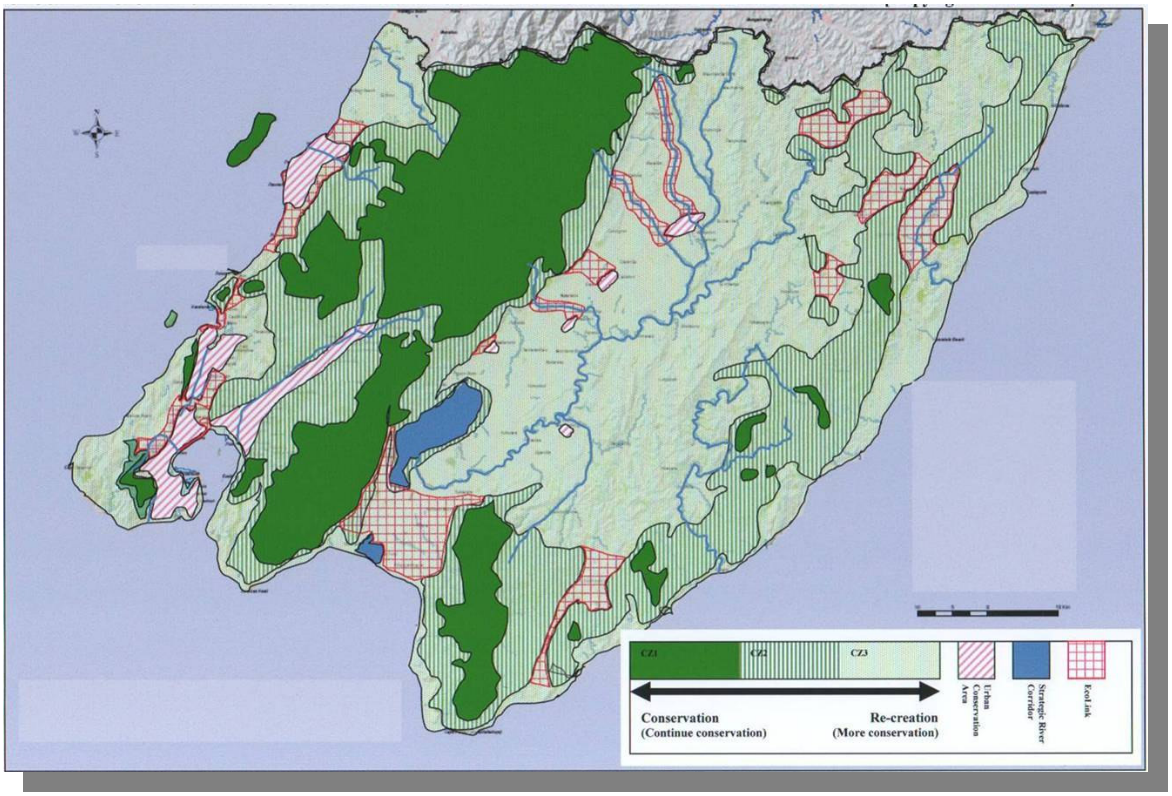
The core areas identified in the ecological network map (**Figure 14**) developed in Step 4 above and the land use classes listed in **Table 22** formed the foundation elements for delineating five broad landscape elements and 'conservation management zones' shown in **Table 23**.

Table 23: Biodiversity 'Zone' Characteristics, Function and Management

Characteristic	Ecological Function	Management Zone	Management Type	Map Colour
Remnant Forest	Core Area	Conservation Zone 1 (**CZ1**)	Conservation	
Grey scrub /exotic forest	Buffer & ecolinkage	Conservation Zone 2 (**CZ2**)	Conservation, re-creation & production	
Farmland	Eco-re-creation	Conservation Zone 3 (**CZ3**)	Production & re-creation	
Urban areas	Protection, recreation & ecolinkage	Urban Conservation Zone (**UCZ**)	Recreation & restoration	
Lake, river & stream	Connecting corridor & habitat	Strategic Riparian Corridor (**SRC**)	Protection & restoration	
Ecolink	Connecting corridor or stepping stone	Special Restoration Zone (**SRZ**)	Restoration & recreation	

These 'zones' were then applied to the land cover base map according to the land cover class. Major breaks between core/buffer zones and between urban and core/buffer zones were then identified as special restoration zones or potential ecolinkages (ecological corridor or stepping stone patches). The seventh class of management zone class – Special Restoration Zone - listed in **Table 23**, was then added to the map as an overlay. The outcome of this process is the **strategic biodiversity conservation map** for the Wellington Region shown in **Figure 15** (See also enlarged map **Appendix L**).

Figure 15. Strategic Biodiversity Conservation Map for the Wellington Region
(See **Appendix L** enlargement)



STEP 6: DETERMINE ZONE POLICY OBJECTIVES AND IMPLEMENTATION OPTIONS

Each zone on the map has a corresponding policy and accompanying suite of management tools to facilitate implementation (based on Catchpole, 2006:26-27; Noss & Cooperrider, 1994:174-177). **Table 24** (Also **Appendix M**) represents the kind of policy development and implementation options that could be employed by regional and local authorities to ensure appropriate actions are undertaken to improve sustainable biodiversity conservation outcomes. Communities, property owners, individuals, sectoral interests and other stakeholders should be actively engaged in development of policy and implementation options through workshops and focus group discussions. Monitoring will form a critical part in gauging short and long-term outcomes of implementing the strategic plan.

Table 24. Policy Guide - Conservation Zone Policy Development & Implementation (also **Appendix M**)

Zones		Biodiversity Characteristics	Policy Development	Policy Implementation
HABITAT CONSERVATION, ENHANCEMENT & RE-CREATION AREAS	CZ1	**CORE AREA** Protected indigenous forest	Policy should recognise and seek to maintain &, where necessary, restore the biodiversity resource	Decisions should ensure the maintenance &, wherever possible, support maintenance & restoration of the integrity of the biodiversity resource • Active plant and animal pest management, as feasible • Minimise exotic incursion by avoiding or minimising roading or road reconstruction within core areas • Limit track systems in and through core areas. • Where possible, close, obliterate and revegetate roadbeds. • No off-road vehicles or other motorised equipment or mountain bikes. • Initiate land acquisition or covenant programs for critical unprotected lands • No grazing by domestic livestock • No horses • No resource exploration or mining • No collection of plants or other natural objects for commercial purposes. • Hunting permitted of introduced animals only as authorised • Tramping, basic camping, nature study, environmental education and non-manipulative (except restoration) research encouraged
	CZ2	**BUFFER ZONE** Unprotected indigenous & exotic forest Multiple use	Policy should recognise importance of buffers & biodiversity networks & their role in: • protecting core areas • providing additional critical life-cycle habitat • Providing adaptation/ movement habitat potential for climate change And seek to strengthen their integrity by expanding core areas & patches of high quality habitat & enhancing connectivity. Opportunities for strategic habitat restoration should be sought	Decisions should seek to expand & enhance networks & seek to strengthen them by contributing to the strategic recreation of habitats • No logging of primary forest where possible • Limited new road construction or reconstruction • Gradual reduction of road density, except where higher densities are necessary to access and operate private property • Initiate covenants and management agreements with private owners • No motorized off-road vehicles on public lands • Active plant and animal pest management on pubic land, as feasible • Establish protection & restoration incentive programs
	CZ3	**ECOLOGICAL RE-CREATION ZONE** Developed landscape. High quality habitat is restricted to isolated sites, separated by large areas of farmland &/or rural urban areas	Policy should recognise & protect isolated biodiversity features & encourage their expansion. Policy should also recognise the importance of ecological networks & the need & opportunity to reconnect the functional ecological landscape	Decisions should protect remnant biodiversity features & seek opportunities to expand, buffer and reconnect them, thereby providing increased protection from external impacts. • Protect riparian corridors and other sensitive sites • Moratorium on development in all natural or near-natural habitats, instead channelling development into areas already developed or degraded • Use road/rail networks, shelterbelts & river corridors to increase habitat & reconnect the ecological landscape • Initiation of restoration projects, both short and long term • Initiate public education programs and establish community partnerships on biodiversity conservation and restoration • Establish protection & restoration incentive programs

	ECOLINK (CORRIDOR)	**SPECIAL RESTORATION AREA** Priority potential connectivity 'corridors' in currently developed or threatened agrarian landscape	Policy should encourage recreation & restoration of multi-functional, semi-natural habitats. Policy should recognise the need & potential for reconnecting the ecological landscape through developing corridors & stepping stones through a mixture of roadside, riparian & fenceline planting of appropriate native-friendly plants	Decisions should accommodate and allow for restoration of multi-functional, semi-natural habitats. Consider tools such as • Use road/rail networks, shelterbelts & river corridors to increase habitat & reconnect the ecological landscape • Encourage protection & enhancement of indigenous remnants as basis for habitat and stepping stone linkages • Initiation of restoration projects, both short and long term • Build stakeholder partnerships • Initiate strategic education programs and community partnerships • Provision of plants free or at-cost for target areas • Encourage community restoration groups
	URBAN CONSERVATION AREA	**URBAN CONSERVATION AREA** Dominated by built environments, and isolated patches of exotic and regenerating native vegetation of various sizes	Policy should recognise habitat value and potential of urban area and protect existing biodiversity resources	Decisions should protect and enhance existing remnants and encourage development of new habitat through a mixture of: • Promoting vision for urban biodiversity • Identify, protect or restore urban ecological components – core, linkages, buffers • New subdivision control – retain & enhance native vegetation, education on plant and animal pests, structure plans • Urban education programmes • Establish protection or restoration incentive programs (e.g., provision of plants free or at-cost for target areas, etc)
	STRATEGIC RIVER CORRIDOR	**RIPARIAN AREA** Represents the regions core river & floodplain resource & role as existing or potential strategic habitat corridor	Policy should recognise & seek to maintain & restore the biodiversity resource and critical role as ecological corridors and provision of ecological services	Decisions should ensure the maintenance &, wherever possible, restoration of the functionality of the biodiversity resource. This will include protection &, wherever possible, the recreation of suitably planted riparian strips while avoiding obstruction of river. A buffer (fenced) zone around significant lakes (e.g. Lake Wairarapa)

STEP 7: MAP AND APPLICATION TESTING - INTERVIEWS

The maps and the general policy and implementation framework for each zone in the Wellington Region were then 'tested' during interviews with a leading international landscape ecologist and biodiversity specialists familiar with the Wellington region (See list of 'test panel' in **Appendix I** and summary of interviews in **Appendix B**). Copies of early drafts of the regional ecological network, strategic biodiversity map and policy matrix were shown to these specialists. There was general support for the spatial layout and policy direction and implementation options.

Forman (Pers.comm. 2006), while not familiar with the Wellington region, was encouraged by the scale and scope of the area and the intentions of this application of the LEEP model. He would have favoured starting with a landscape map for the whole of New Zealand and doing the same exercise at the national scale – something the author would like to do, but for the reasons given in **Section 5.2** the Wellington region was chosen as a useful and manageable mapping unit for this exercise. Forman liked the concept of corridor linkages especially that suggested for reconnecting the axial Rimutaka Forest Park with the Haurangi Forest Park. He agreed with identifying the unique and significant features such as Lake Wairarapa, cities, big patches and main river corridors and investigate how the arable matrix effects patches and vice versa. He believed it was important to consider climate change impacts for the region, particularly the impact of a wetter west and a drier east – to ensure the maps were strategic and forward looking. He would have preferred a greater emphasis on making the significant “patches” (core areas) bigger, an approach this study is mindful of in deciding eco-restoration priorities for the Wellington region in the future.

Saunders (Pers.comm. 2006) was positive about the general layout and content of the maps and matrix. He suggested that any biodiversity conservation programme based on such maps should be ‘costed’, and recommended that should be done by a resource accountant (e.g. Ross Cullen at Lincoln University). The author recognises that any strategic biodiversity plan prepared by local authorities would require that costs and benefits of restoration be assessed before implementing any plan. Saunders was particularly concerned about the implication of the map for the loss of productive land from implied tree planting and the purchase of land to accomplish restoration or protection. This is an important issue and is identified as one of the ‘Future Research’ needs recognised in section 6.4 and other thesis conclusions. Forman (Pers.comm. 2006) strongly supported the possibility of carbon credit funding paying for all or part of such programmes.

Simpson (Pers.comm. 2007) was excited by and supportive of the ecological network and strategic spatial map for Wellington. He appreciated that the concepts behind the map were ‘not new’, rather being a development of and entirely consistent with his own maps and recommendations in his DOC report (Simpson, 1997). He was particularly passionate about moving beyond ideas and spatial policy to see application on the ground. He believes two keys for implementation of such maps are their translation into farm plans, funding this and a strategic planning programme. Both are reflected in the policy guide (**Table 24**) above, the implications for agencies identified in **Section 5.5**, and the conclusions of **Chapter 6**. Simpson believes that partnerships with sectoral interests are also crucial to effective and sustainable implementation, a critical aspect also recognised in the policy guide (**Table 24**) above.

Ogle (Pers.comm. 2007) also supports this research and the maps, but, like Simpson, also made the point that concepts and maps are not new. He thinks the idea of reconnecting the Rimutaka Forest Park area with the Haurangi Forest Park with shelterbelts, roadside planting and an appropriate landscape matrix is a good one. He also agrees that urban areas should be conservation areas and that such areas need more not less conservation as suggested by the maps. He would like to see development of an example of a smaller scale strategic plan – perhaps of the Rimutaka/Haurangi corridor – to illustrate how it would work at a more detailed scale. Such an example was developed and included in the following **Section 5.4** and **Figures 16** and **17**. He was interested in the work by Blaschke et.al (2004) in developing a restoration plan for the Kaiwharawhara catchment within the Wellington urban area. He pointed out that biodiversity at Pukerua Bay and the Taupo Swamp areas must have increased and warrants recognition and placement in any regional strategic plan, as a result the final maps were amended to include this area as a core patch and an ecolinkage identified to reconnect the area to the axial range core. Ogle was interested in the work of Manning *et al* (2006) on the significance of small remnants in modified landscapes that suggested they are or could be significant centres for restoration and as stepping stone ecolinkages. The appropriate papers have since been supplied to him.

Park (Pers.comm. 2007) was encouraged by and very encouraging of the work and believes it is an important illustration for conservation planner and managers of what the future will look like. The maps are consistent with his own work (Park, 1998, 2000) and thoughts on the need for a more strategic approach to conservation and ecosystem management in New Zealand. He mentioned he has a crib in the lower Wairarapa Plains and has observed *kereru* (native wood pigeon) flying between and Rimutaka and Haurangi Forest Parks that suggests these and the movement of other native species could be facilitated by developing an ecolinkage between these two large indigenous patches.

Miskelly and Flavell (Pers.comm. 2007) were also both interested and very supportive of the maps and their potential applications. For example, they could particularly provide a basis for investigating and setting priority restoration and corridor areas, especially the suggested Rimutaka/Haurangi ecolink. Miskelly was particularly interested in the potential for using the maps to generate tradable carbon credits, provide an incentive for revegetation, and fund eco-restoration projects.

These responses to the maps and policy matrix developed using the LEEP Model for strategic biodiversity conservation planning provide general support for the concepts, spatial pattern and policy and management options for implementing such a strategy. A number of suggestions for improvement have been included in the maps or the appropriate other sections of the thesis. Particular interest was expressed by a number of the 'Test Panel' in the potential to establish an ecolinkage between the Rimutaka and Haurangi and Forest Parks as a way of reconnecting the isolated indigenous remnants of the east Wairarapa with the central core remnants associated with the main north-south axial ranges traversing the centre of the Wellington region. As a result, further work was done on this are and inserted as **Section 5.4** and **Figures 16** and **17** as an example of smaller scale, more detailed application of the strategic maps and landscape ecology concepts. From a socio-political perspective, these strategic maps and any smaller scale maps could be refined further by discussion with local scientific, sectoral, environmental and community groups and landowners.

5.4 EXAMPLE - APPLICATION OF LEEP MODEL TO PRIORITY LOCATION

The LEEP model can be applied at smaller scales – territorial authority districts, catchments or key protection or restoration areas identified from the regional biodiversity map – and provide more detailed application of the model, ecological design guide and policy implementation guide. An example has been developed for the potential ecolinkage to reconnect the Rimutaka and Haurangi Forest Parks across the lower Wairarapa Plain and to illustrate 'What it would look like'.

Figure 16 represents an enlargement of the Rimutaka/Haurangi ecolinkage area from the regional strategic biodiversity map (**Figure 15**). The land cover map (**Figure 13**) shows the area covered by the proposed ecolinkage is mostly pasture, with few indigenous remnants, particularly the central area. The plain is crossed by a relatively sparse network of local roads and a few rivers and streams. Core areas, and potential buffers and ecolinkage are identified.

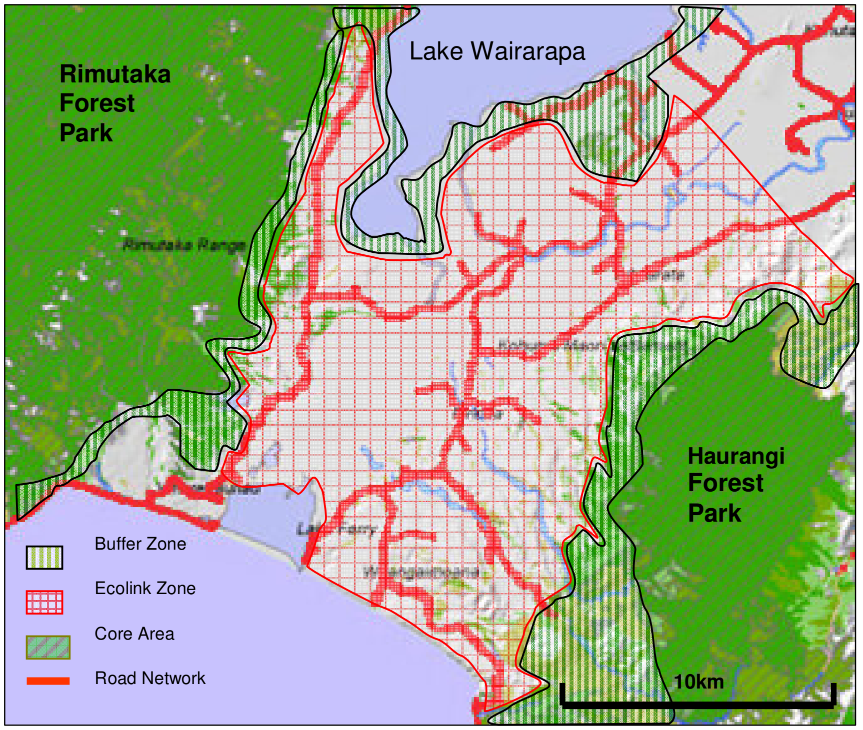


Figure 16. South Wairarapa Area – Potential Ecolink.

Figure 17 translates the strategic zones of the lower Wairarapa area into potential ecological landscape elements for implementation on the ground.

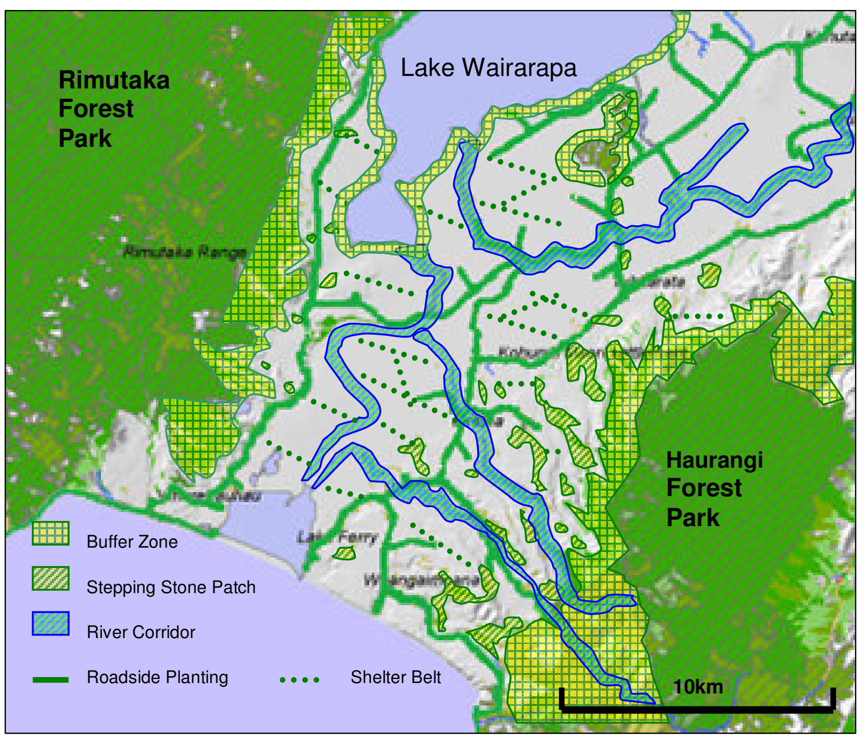


Figure 17. South Wairarapa Area - Potential Development of Ecolink

The location and size of these elements are only indicative. Not all or every part of an element may be necessary or possible. Options are an important aspect of detailed planning. Even more detailed planning can establish actual locations for shelterbelts and roadside revegetation, for example. An illustrative policy and implementation guide for each element is produced in **Table 25**.

Table 25. Example Policy and Implementation Guide for South Wairarapa Ecolinkage Development

Element	Policy	Implementation
Core	Restore & maintain, and where possible, enhance biodiversity resource & resiliency	• Plant & animal pest management • Limit road & track access • Expand protected core area by strategic purchase, covenanting & revegetation
Buffer Zone	Protect and extend core area habitat & enhance the ecological network to provide additional life-cycle habitat & adaptation/ movement habitat potential for climate change	• Protect native forest from logging • Strategic habitat restoration • Limit new road construction • Decisions should seek to enhance networks & strengthen them by contributing to the strategic re-creation of habitats • Initiate covenants with private owners • Plant & animal pest management on public & private land • Establish protection & restoration incentive programs
Stepping Stone Patch	Protect isolated native forest patches & encourage their expansion. Recognise the importance of ecological networks & the need & opportunity to reconnect the functional ecological landscape	• Protect, expand, buffer & reconnect strategic forest remnants • Fencing • Plant & animal pest management • Expand through use as replanting centres • Covenant or purchase strategic patches • Education and land care programmes
River Corridor	Recognise critical role of this natural network as existing & potential ecological corridor. Recognise environmental services of riparian areas. Protect & enhance corridor vegetation	• Protect & replant riparian strips • Fence riparian strips • Plant & animal pest management • Stop or minimise stock access • Education & stream care programmes
Roadside Planting	Recognise ecological corridor potential of roading network	• Protect & establish strategic roadside planting with appropriate hardy native species • Plant & animal pest management • Education & land care programmes
Shelter Belt	Recognise ecological corridor potential of farm shelterbelts, hedgerows and woodlots.	• Establish education programmes and partnerships with landowners/farmers • Sympathetic management of existing shelterbelt & woodlots • Establish new plantings using vegetation friendly to native species • Plant & animal pest management

This output can assist protection of indigenous remnants and improve others, and increase the level of connectivity and ecological functionality across the local landscape that may also have significant benefits for regional and national biodiversity and ecosystem dynamics and resiliency. This enhanced landscape mosaic may also provide a range of environmental services such as wind breaks for stock and crop protections, erosion control, flood reduction, enhance aquifer recharge and assist pest management. Developing and achieving an effective ecolinkage will require specialist expertise, strategic partnerships and community/stakeholder involvement. Maps developed using the LEEP model can be an important tool not only in the design of ecolinkages, but also in explaining, envisioning and recruiting stakeholder and community commitment and participation.

5.5 IMPLICATIONS FOR AGENCY RESPONSIBILITIES

The implementation of this spatial approach to strategic biodiversity conservation has implications for several government and non-government agencies. **Table 26** lists those agencies and outlines potential action points for each. Ideal and most effective implementation of the LEEP model would require integrated and coordinated involvement by all these agencies. But improved biodiversity outcomes could be achieved by partnerships between any of these agencies. A pilot programme between at least two agencies could provide a useful demonstration of principles and processes and encourage other agencies to join the partnership.

Table 26. Agencies and Responsibilities for Implementation of LEEP Model in the Wellington Region

Agency	Possible Action
Ministry for the Environment	• Amend RMA requiring strategic approach to biodiversity planning by local authorities as mandatory • Reconsider need for a National Policy Statement & opportunity provided by LEEP model (in partnership with DOC) • Establish directions & standards/guidelines for strategic biodiversity conservation planning in conjunction with DOC. • Capacity build in the nine constituent local authorities in the Wellington Region • Develop national educational resources for biodiversity planning & explaining landscape ecological principles • Initiate partnerships to develop industry standards for biodiversity protection & enhancement
Greater Wellington Regional Council	• Undertake & implement the critical strategic biodiversity conservation plan • Develop regional multi-sectoral partnerships to advise & lead biodiversity planning • Identify priority region-wide biodiversity projects, methods & incentive programmes
District Councils (8)	• District plans & biodiversity work to reflect strategic priorities identified in regional biodiversity strategy along with locally significant projects consistent with this strategy • Consider strategic planting along roadside verges in buffer & ecolinkage restoration areas • Direct urban development away from identified existing & potential biodiversity resources • Develop rural & urban subdivision standards to protect & enhance indigenous remnants & other biodiversity resources
Department of Conservation Head Office	• Reconsider need for a National Policy Statement & opportunity provided by LEEP model • Adopt a strategic approach to biodiversity conservation to assist existing biodiversity work • Develop guidelines for DOC participation in regional & local strategic biodiversity planning in consultation with MfE • Specifically resource the DOC activities to accomplish strategic biodiversity planning • Undertake field research on priority aspects of elements of strategic biodiversity planning

Table 26. Agencies and Responsibilities for Implementation of LEEP Model in the Wellington Region (Cont'd)

Agency	Possible Action
Department of Conservation Wellington Conservancy	• Develop and implement CMS consistent with a strategic biodiversity conservation approach • Greater involvement in RMA processes to achieve key biodiversity gains for conservation estate and on private lands with significant biodiversity values • Increase capacity to participate in formal and informal RMA processes • Partnership with regional and district councils in development of the Regional Policy Statement, and regional and district plans
Iwi	• Recognise strategic biodiversity conservation planning provides significant opportunity to protect and enhance natural *taonga* and sustain traditional uses • Partnership with MfE, DOC, regional and district councils in identifying biodiversity resources and processes and the development of a strategic biodiversity plan • Development & management of an Iwi Plan for Maori land consistent with the strategic biodiversity plan
Farmers/Landowners	• Develop farm plans, shelterbelts, riparian protection, and indigenous remnant enhancement consistent with identified priorities in strategic biodiversity conservation plan. • Develop clusters of farmers/landowners as biodiversity conservation project groups • With the help of DOC & regional council upskill farmer/landowners
Landcare Research	• Undertake research on priority aspects of elements of strategic biodiversity planning and critical aspects of field components such as corridor effectiveness.
QEII National Trust	• Prioritise covenant & remnant protection consistent with strategic regional goals • Promote covenanting within identified strategic areas as a priority
Animal Health Board	• Coordinate animal pest control operations with other agencies (e.g., DOC & regional councils)
Environmental NGOs	• Partnership with DOC and regional councils in implementing strategic biodiversity plans • Promote and undertake projects consistent with priorities identified in the strategic biodiversity map.
Land & stream care groups	• Take a more strategic approach to project location and the kinds of work undertaken consistent with strategic biodiversity map • Establish new groups based on strategic regional priorities
Ministry of Transport	• Consider opportunities that road and railway verge networks can contribute to enhancing regional and local biodiversity connectivity • Establish appropriate guidelines for management of road and rail reserve consistent with local and regional biodiversity conservation priorities

5.6 WELLINGTON APPLICATION CHECKLIST

The application of the LEEP approach to the Wellington Region – its processes, methodology and purpose – is modelled on and consistent with the approach demonstrated by English biodiversity conservation planning (see **Table 13, Section 2.3.4**). The following **Table 27** uses good practice principles established for opportunity mapping projects in England (see **Section 2.3.4, Table 13**) to provide a useful checklist for the LEEP Model and its application to the Wellington region. It summarises the degree to which the Wellington case study reflects these good practice principles and therefore likely to produce defensible improved conservation outcomes.

While the processes and communication methodology used in the Case Study would need to be expanded and adapted for broader sectoral and public presentation, the current select audience provided an encouraging indicator of the suitability and 'understandability' of the maps, potential processes to involve wider participation, and acceptance of the general methodology used in producing the maps and policy guide.

Table 27. Checklist - Good Practice Principles for Strategic Biodiversity Conservation Maps

	LEEP Model Characteristics	Wellington Case Study Check	
PROCESS	Links from and to the BAP	✓	Consistent with NZBS, RMA and original RPS and CMS (that were not implemented)
	Strong partnerships from the outset	✓	For purposes of this study 'Partnership' was through existing publications and use of Test Panel of specialists. Next step would involve community
	On-going partnerships	✓	Model has already produced support from DOC & GWRC. Effective implementation requires the next step would involve establishing partnerships with key stakeholders identified in **Table 26**
	Continuity across boundaries and scales	✓	Provides continuity across districts providing guidance to smaller scale, Conscious of expanding into adjacent regions and developing a network of inter-regional maps
	Dialogue with local expertise	✓	Interviews with the individuals of 'Test Panel' provided suitable expertise for this study
	Links to other sectors	✓	Clearly signified in Policy Matrix (**Table 24**) and identified responsible agencies (**Table 26**)
METHODOLOGY	Use the best data available	✓	Use of LCDB2 as base map
	Complexity in keeping with purpose	✓	High-level,, strategic application reflected by basic simple application
	Use an ecological rationale	✓	Based on principles of landscape ecology and English biodiversity planning model which is also based on a landscape ecology approach
	Use a landscape framework	✓	Covers regional scale
COMMUNICATION	Design the map to suit its purpose	✓	Based broad land cover classes and fundamental landscape elements – core, buffer, ecolinkages and matrix
	Understandable to look at	✓	Audiences have demonstrated understanding and response has been positive
	Careful wording to accompany the map	✓	Clear legend and accompanying colour-consistent policy matrix
	Use right media to communicate the map	✓	PowerPoint and hardcopy maps and policy matrix presentation with accompanying explanation

5.7 FUNDING SOURCES

Funding for strategic mapping, identification of priority objectives, development of strategic policy, and protection and restoration programmes will be critical to achieving more effective and sustainable biodiversity conservation for the Wellington region. Key in this will be the inclusion of this work with the strategic thinking and policy directions of DOC and Greater Wellington Regional Council (GWRC) and a commitment to allocate resources for mapping programmes within their long-term planning strategies and annual budgets. Without the involvement and commitment of these agencies, it is likely that biodiversity conservation in the Region will remain *ad hoc* and inconsistent and ineffectual.

Assuming that both DOC and GWRC adopt the kind of strategic approach suggested by the LEEP Model, there are numbers of funding opportunities available for communities, environmental groups and private landowners to assist strategic conservation and eco-restoration projects. **Table 28** lists and summarises some of the funding sources available in the Wellington region for a broad range of environmental work, including plan preparation and education programmes.

Table 28. Funding Sources for Community and Private Conservation and Eco-restoration

Agency	Fund	Purpose and Criteria	Funding
DOC	Biodiversity Advice Fund	Enhancement of biodiversity on private land – focuses on information & advice to land managers to better protect indigenous species on their land	-
	Biodiversity Condition Fund	Enhancement of biodiversity on private land to improve & maintain the condition of areas of indigenous vegetation, species and habitat. e.g. fencing, pest control	Max $60k per year. 3yr max
	Nature Heritage Fund	Protect indigenous ecosystems that represent the full range of natural diversity originally present in the New Zealand landscape through legal &/or physical protection e.g. direct purchase, covenanting & fencing	-
	Nga Whenua Rahui	Protect indigenous ecosystems on Maori land through physical protection (e.g., fencing & pest control), covenanting & reservation	-
	Matauranga Kura Taiao	Support traditional Maori biodiversity management incl. wetland restoration, nursery development, regional workshops for hapu & iwi to increases capacity to manage their natural resources	-
MFE	Sustainable Management Fund (SMF)	Support community groups, iwi, business & local government taking practical action that produces long-term environmental benefits. Programmes that directly support land & water management, sustainable business practices, or meet challenges of climate change	3 yr max $10k-$200k max

Table 28. Funding Sources for Community and Private Conservation and Eco-restoration (Cont'd)

Agency	Fund	Purpose and Criteria	Funding
MAF	Sustainable Farming Fund	Improve environmental performance & overcome barriers to social, environmental and economic viability. Communities of interest with shared problem & opportunity in sustainable use of a resource	Up to $20k regional projects. Over $20k for national projects
Lottery Grants Board	Environment & Heritage Fund	"One-off" projects seeking to promote, protect & preserve New Zealand's natural heritage – habitats & ecosystems, incl. education & awareness programmes; plans & reports; wetland and forest restoration; nursery establishment; salaries; pest eradication; research and monitoring. Priority to projects with ⅓ of costs already secured. Private work on private land is ineligible	Small and large sums
QEII Trust	Covenants	Assist landowners legally protect wetland and bush on their properties using covenants. Share legal, fencing and survey costs. Contribute to weed and pest control on covenanted lands	Cost sharing
GWRC	Take Care	Financial support & specialist assistance for local community environmental programmes seeking to contribute to the health and restoration of indigenous ecosystems, incl. ground preparation, replanting & maintenance; environmental monitoring; signage; project plans & landscape design; leaflets & promotional activities; meeting costs; & environmental education	-
	Wetland Incentive Programme	Wetland restoration programmes on private land	Contestable $40k available each year
	LTCCP	Financial assistance to qualifying' projects & programmes through submission to LTCCP process for inclusion in 10 yr plan process	-
WWF	Habitat Protection Fund	Restoration & conservation of critical indigenous terrestrial & freshwater habitats & ecosystems incl. replanting, environmental education & capacity building, community employment opportunities	$2k-20k
Fish & Game NZ	-	Advice & support	-
NZ Game Bird Habitat Trust	-	Wetland or habitat enhancement	Up to 50% financial support
Territorial Authorities	-	Various internal funds and assistance and external trusts (check with target council)	-

Philanthropic Trusts	-	Fund capital works and project packages for a range of projects incl. environmental – Wellington e.g. incl. Taylor Trust, Trust House, Southern Trust, Todd Foundation	-
Corporate Funds	-	Individually negotiated partnerships that may include resourcing projects and programmes	-

Further details are available from the websites of the agencies identified. The Funding Information Service (www.fis.org.nz) has information on other funding sources for environmental projects.

Table 28 demonstrates there is a wide range of funding sources particularly available for private sector conservation initiatives. Some territorial authorities (e.g. Wellington City, Kapiti Coast) are leading the trend towards more sustainable development options involving biodiversity protection. These initiatives need the strategic direction that only DOC ad GWRC can give. Partnerships between the public and private sector are essential to ensure funding and other resources are directed towards projects and programmes that will provide the most effective, long-term benefits for biodiversity conservation the Wellington region.

5.8 CONCLUSIONS

Following the approach developed in **Chapter Four** and consistent with the international literature reviewed in **Chapter Two**, application of the LEEP Model for strategic biodiversity conservation to the New Zealand context as shown in this Chapter has been shown to be a technically simple, visionary, comprehensive, integrative and potentially powerful tool to facilitate strategic biodiversity conservation planning. The model has a number of advantages and potential significant benefits at any scale of application, but particularly at the regional or landscape level as shown by the Wellington Case Study:

1. The principles behind the model have widespread international acceptance and provide credibility;
2. The steps for developing these maps are straight forward;
3. The LCDB2 database is readily available and easily manipulated to provide an appropriate base map for the model;
4. Maps are based on ecological principles and their detail tested and refined by local expertise;
5. Maps produced by this method have a number of applications that are useful to conservation and development agencies;

6. The policy and implementation framework applying to management zones is transferable and adaptable to maps produced for any region and scale;
7. The maps visually demonstrate how landscape patterns impact biodiversity dynamics;
8. The maps not only define existing biodiversity resources, but have the advantage of representing landscape dynamics (real or potential) and opportunities for enhancing large and small scale ecosystem health;
9. The processes and methodology used in the development of the maps and the communication options can be adapted for different purposes and different target audiences;
10. The model can be easily applied and resulting maps by any or all agencies, interest groups or individuals;
11. Funding sources are available that can facilitate any or all parts of a strategic mapping and implementation approach suggested by the LEEP Model.

With these advantages, the process and product should be an attractive tool for any agency or organisation involved in environmental planning or biodiversity conservation.

CHAPTER SIX – CONCLUSIONS

6.1 IMPORTANCE OF THE 'LEEP' MODEL

Application of the LEEP Model for strategic biodiversity conservation as described in **Chapter Four** and demonstrated in the New Zealand context through application to the Wellington Region in the Case Study in **Chapter Five** has been shown to be technically simple, visionary, comprehensive, integrative and potentially quite a powerful tool to achieve more effective conservation planning. The LEEP Model has a number of potential significant benefits:

- It may be applied at any level and depth – more 'science' simply refines details.
- It can provide impetus for win/win situations for conservation and development. In this Model these traditionally conflicting activities have a potentially symbiotic and complementary relationship. These two broad land uses can be recognised, legitimised and integrated in a comprehensive way that ensures, or at least maximises, functional ecological landscapes while recognising development needs and the contribution sensitive management of modified landscapes can contribute towards more effective and sustainable ecological, as well as social and economic outcomes.
- It provides an important shift from solely traditional conservation methods that demonstrates and initiates a new kind strategic thinking about a spatial ecological framework which may be usefully applied at a variety of scales, particularly regions. This spatial framework is a significant strategic tool for defining or redefining conservation priorities and projects.
- It provides a framework for bridging the 'implementation gap' identified in **Chapter One** between ecological knowledge, policy objectives for an ecosystems approach to biodiversity planning, and real, on-the-ground benefits to the functional ecological landscape and the natural processes, species and habitat these landscapes contain.
- Landscape ecologists agree (Pers.comm. Forman 2006, and Ogle, Park and Simpson, 2007) that the major strengths of the LEEP Model are that it, 1) provides a strategic spatial view of the biodiversity resources and dynamics with any given area; 2) allows identification of more strategic conservation priorities beyond simply isolated habitat and species; 3) promotes the integration of disciplines, interests and contributions from agencies, organisation, communities and landowners; and 4) answers a historical call from leading conservation thinkers in New Zealand for such an approach.

Strategic biodiversity maps and accompanying policy matrix developed from application of the LEEP Model provide broad policy guidance and implementation options for biodiversity conservation that may be used to prioritise, integrate, guide and facilitate conservation initiatives.

The integration of the literature on landscape ecology and the English planning framework in the LEEP model is an important contribution to conservation policy and planning in New Zealand for a number of reasons:

- It demonstrates that New Zealand is currently out-of-step with mainstream international thinking and application of landscape-scale ecological planning by continuing to largely ignore its increasing widespread application and recognised potential benefits overseas.
- It has significant potential to provide a strategic spatial context for conservation activities, enable non-specialists to ‘make sense’ of spatial conservation strategies and to then better recruit public support for participation in small scale components of large scale conservation programs.
- It breaks down the artificial boundary between public and private land and the kind of differential approaches to conservation that currently occur with indigenous remnants by recognising that ecosystems and functional landscapes transcend such artificial boundaries.
- It breaks down the traditional conflict in New Zealand between conservation and development whose goals have been considered mutually exclusive by respecting, coordinating and overlapping provisions for both needs.
- It highlights that a new set of skills are required to achieve conservation outcomes in the twenty-first century – skills in interpersonal relationships, negotiation, partnerships and building consensus - because socio-political processes are important to effective and sustainable ecological outcomes.
- If applied, the LEEP model has the real potential to build on and extend the gains of traditional conservation methods – species recovery, off-shore island sanctuaries and pest management – to protecting or restoring functional and sustainable mainland indigenous ecosystems.
- It fills the implementation gap identified in **Chapter One** between the legislation and policies of the RMA, NZBS and Conservation Act and the actual on-the-ground action on those policies.

One major objective of this thesis was to provide the means to close the 'implementation gap' in conservation policy identified in **Chapter One** and improve effectiveness of conservation planning by increasing the level of integration between the science of landscape ecology and discipline of land-use planning – the 'BC' (Improved Biodiversity Conservation) overlap in **Table 9, Chapter Four** . It is hoped that application of the principles and practice described and discussed in this thesis will go a significant way to fulfilling Goal Three of the NZBS – Halting the decline of New Zealand's biodiversity.

6.2 EVOLUTION INTO THE FUTURE

The principles and steps encompassed by the LEEP Model are transferable to other biodiversity conservation contexts. The kind of strategic biodiversity mapping work and policy/implementation guide demonstrated by the Wellington Case Study can be transferred to other landscape scales and other kinds of ecosystems besides terrestrial ones. Key areas in which the model could be used include:

1. **Other regions of New Zealand**. Adjacent strategic biodiversity maps can be joined into appropriate 'super' regions particularly where the identification and protection or enhancement of cross-boundary issues are critical. Eventually, these regional maps can be joined together to form a national ecological network and strategic biodiversity map to further aid in setting national priorities for maintaining functional connectivity and ecological landscapes. This will also further contextualize regional biodiversity maps and national biodiversity opportunities and priorities.
2. **District or sub-regional plans**. Once strategic regional biodiversity conservation mapping is done and conservation priorities established, smaller scale district biodiversity planning and activity can then occur within the regional context and priorities. District planning is a critical level of the New Zealand planning framework that controls land-use activities, subdivision design and promotes ecologically sensitive land management practices at the individual land parcel level.
3. **Other environments**. The LEEP model may be extended for use in marine, wetland and freshwater aquatic systems. For example, marine parks and other areas rich in marine or aquatic biodiversity represent core areas around which buffers and ecolinks are planned within a more highly modified (and fragmented and depleted) matrix. Internationally, the principles of landscape ecology have been applied to coastal, marine, wetland and freshwater ecosystems. Most recently, for instance, the Great

Barrier Reef Marine Park has been created using a landscape ecology and ecological network approach.

4. **Other bioregional contexts outside of New Zealand**. The same principles and modelling can be applied to natural systems outside of New Zealand.

More immediately, for the New Zealand context, it is envisioned that the following broad steps are needed to begin wider implementation of the LEEP Model and the kind of values and principles underpinning it:

1. Adopt and implement the model at a national level of government involving the following steps:
    a. Identify a lead agency or government minister (e.g. MfE or DOC) to convene a meeting of key agencies involved in conservation and environmental management (i.e. MfE, DOC, Maori representatives, MAF, RFBPS, Fish and Game, QEII National Trust, Landcare Research) to consider and commit to adopting the integrated approach to biodiversity conservation demonstrated by the LEEP Model. This group develop a national policy framework for implementation of a strategic approach to biodiversity conservation.
    b. Commit resources to identifying and developing a national ecological network and identifying a national plan based on priority areas and/or identifying a suitable region to develop a pilot programme to extend and demonstrate the practical application of a regional biodiversity map and plan based on the LEEP Model.
    c. Establish a pilot programme involving regional partnerships of key agencies (DOC, regional and local councils, RFBPS, Fish and Game, Landcare Research, QEII National Trust, Federated Farmers) to undertake the following action:
        i. Oversee and develop a regional ecological network and strategic biodiversity map and plan for the region.
        ii. Ensure strategic objectives identified in the regional ecological network and the biodiversity map and plan are appropriately reflected in the biodiversity provisions of district plans.
        iii. Develop a process and communication plan that is inclusive, informative and educational to recruit public and specific stakeholder

support and involvement in implementing relevant aspects of biodiversity conservation plans.

iv. Identify and resource specific research needs to refine and improve implementation and practice.

v. Monitor the implementations and medium and long-term outcomes of the plan. Review and amend priorities and practice accordingly.

d. 'Roll Out' similar map production and plan development and implementation to other regions, recognising cross-boundary issues and consistency of approach.

Failing a national approach being taken, a key regional agency (such as DOC, or in the case of Wellington, the Greater Wellington Regional Council) could initiate its own regional biodiversity partnership and establish a pilot programme to identify, develop, adopt and implement a regional strategic biodiversity conservation map and plan similar to that identified in step 'C' above. This may not only provide leadership for the region, but also provide the example and impetus for other regions and eventually development and adoption of a national policy and plan. Whether a programme is initiated at national or regional level, either will require leadership in a strategic approach to biodiversity conservation that has been absent. Leadership remains a critical issue.

6.3 CONTRIBUTION OF THIS THESIS

A major contribution of this thesis is the development and practical application of the LEEP Model which provides a tool for 'big-picture' strategic biodiversity conservation planning mostly absent from current biodiversity planning in New Zealand.

This thesis also provides two other significant contributions to planning and biodiversity literature - theory and practice. Firstly, it identifies and brings together recent thinking on barriers to implementing legislative and policy provisions (RMA, Conservation Act, NZBS) for biodiversity protection in New Zealand and identifies a specific planning/implementation gap (large-scale, strategic spatial planning) in biodiversity planning methodology.

Secondly, it brings international thinking and application on landscape ecology up-to-date through a review of international and New Zealand literature, current application models, and recent interviews with internationally- and nationally- recognised experts in the discipline of landscape ecology. Part of this has been the creation of an updated listing of the 'rules for reserve design' since Diamond's (1975) original rules.

6.4 FUTURE RESEARCH AND APPLICATION OF THE LEEP MODEL

There are at least five potential areas of further research that arise from this thesis. One group of research relates directly to the expansion of the application of the model, a second that looks at improving ecological understanding, a third to investigate alternative mapping methodologies, a fourth that examines improving socio-political processes and outcomes, and final group to explore the ecological and funding opportunities of carbon sequestration programmes and carbon credit markets.

There is a need to research applications of the model in other geographic locations, ecosystems or planning areas of New Zealand or overseas as identified in **Section 6.2**. In the New Zealand context there are at least six broad areas of application research:

- the development of strategic biodiversity maps and policies for all other geographic or administrative regions
- the development of a national strategic map for New Zealand as a whole. This could be accomplished either as a 'top down' exercise from the totally national perspective, or as a 'bottom up' process involving the merging and scaling of regional strategic biodiversity plans
- the development of district or sub-regional plans based on the strategic priorities identified by the appropriate regional strategic maps
- the development of national and regional biodiversity maps for the coastal marine area of New Zealand applying the same principles from landscape ecology
- The development of freshwater aquatic and wetland biodiversity maps for national or regional priority rivers, lakes and wetlands.
- The development of strategic biodiversity maps for other, perhaps more specific and limited ecosystem types such as dunelands, braided rivers and alpine areas.

Strategic ecological research is needed to test or refine the applicability of international landscape ecology assumptions to the unique New Zealand biodiversity context. Research should focus on at least a few key areas:

- The effectiveness of corridors in the New Zealand context for a broad range of different indigenous fauna types – lizards, invertebrates and avifauna. Some work on kiwi has already been done, but needs to be extended. The effectiveness of corridors and buffer zones in fostering protection and expansion of indigenous flora also needs researching.
- The potential negative effects of corridors in increasing movement of mammalian pest species such as possum and mustelids. There may also be a pest management opportunity - if corridors 'channel' mammalian pests, then new more effective pest control or interdiction techniques may possibly be associated with corridors.
- Long-term research into the effectiveness of corridors and ecologic networks where the kind of strategic model promoted in this thesis is eventually applied. Part of this will be developing techniques to monitor and measure the health and health changes in ecosystems associated with application and non-application of strategic biodiversity planning. Another part of this may be to identify or establish 'indicator species' that whose behaviours and very existence act as clear ecological markers for the success or otherwise of establishing more functional and healthier ecosystems
- More detailed research on the regional (and microclimate) impacts of predicted climate change on indigenous flora and fauna, and also animal and plant pest species. This should extend into identifying priority opportunities where strategic biodiversity planning and the establishment of ecological networks could build additional resilience into currently isolated and fragmented remnants and their associated ecosystems.
- Cost/benefit analysis of different landscape ecology tool options (e.g., increasing patch size, developing continuous corridors versus stepping stone or patch matrix ecolinkages, establishing and planting ecolinkages, the impact of restrictive management within designated buffer zones) and their impact on the output from productive land.

Future research and testing of different mapping methodologies is needed to that employed in the Wellington case study. Different methodologies may render improved techniques or describe techniques more suitable to particular purposes. The danger in this, as mentioned in the English planning experience in **Chapter Two**, is the development of a plethora of techniques and no standardisation to provide comparable and compatible outcomes at the national, inter-regional and inter-district level.

The effectiveness of socio-political processes and the outcomes of those processes need to be improved, which may require further research. More effective and sustainable biodiversity conservation outcomes will depend on public participation and commitment. Particular research would need to involve the following:

- Effective methods for accomplishing biodiversity education of the general public and geographically targeted public or sectoral interests.
- Effective processes for achieving public, and particularly landowner, 'buy-in' or participation in strategic biodiversity conservation programmes – national, regional and local. This could involve the development of informational material on key concepts such as connectivity and the establishment and use of corridors.
- Identifying the best ways of using existing environmental policy framework, particularly the RMA, to apply strategic conservation planning objectives across public and private land and at all levels of environmental planning systems – regional district, subdivision and individual land holdings.

The opportunities for significant carbon sequestration gains through protection and extension of indigenous land cover as part of national, regional and local biodiversity restoration programmes would be useful research. There is potential for major eco-restoration programmes or coalitions of smaller programmes to be traded on a carbon credit market (Ministry of Agriculture and Forestry, 2007) and contribute towards funding these programmes, though I am unaware of any such informal or formal provisions in Government policy.

6.5 CONCLUSION

Some of the simply profound ideas are profoundly simple. The idea that landscape patterns influence biodiversity is a simple idea. It is not a new idea. Yet while being increasingly embraced overseas, it has gained only limited recognition and momentum in New Zealand. Calls from leading ecologist for such a landscape-scale approach in New Zealand over the past 30 years have been largely ignored in favour of more traditional conservation methods. Despite the 'success' of island sanctuaries, species recovery and pest management programmes, the loss of indigenous habitat and decline in New Zealand's biodiversity has continued.

Another profoundly simple idea is that the protection of ecosystems protects processes and species within those systems. New Zealand resource management law recognises the importance of ecosystems and their protection. Yet it is debateable whether New Zealand has actually implemented such an approach. We have continued to focus instead on place and species. The results have been encouraging enough to continue, but not lasting enough to ignore the need for other solutions to New Zealand's looming biodiversity crisis.

Humans and human activity as part of ecosystems is another profound and profoundly simple idea. Conservation and human activity need not be mutually exclusive. The recruitment of increased public support and active participation in the conservation effort is critical for any effective, long-term biodiversity conservation outcomes. It is an idea that the Department of Conservation has recently recognised and is currently seeking to alter the specialist and exclusive culture that has pervaded the Department and it predecessors. Significant areas of indigenous remnants and larger ecosystem components exist on private lands. The key to meaningful future conservation gains lies in protection of these areas and mobilising the New Zealand public to take a more active part in the protection of their natural heritage.

These three concepts are at the heart of a landscape ecological approach to biodiversity planning. The LEEP model for strategic biodiversity conservation planning proposed in this thesis provides a framework for integrating and implementing these concepts into a similarly simple and, hopefully comprehensible, approach to conservation across entire ecological landscapes.

There are other advantages to this approach. While this research has only briefly touched on the potential impacts of climate change on biodiversity, a landscape or ecosystem approach to biodiversity conservation is likely to allow for more movement and adaptation of species and build greater resiliency into habitat and populations. Maintenance and enhancement of indigenous land cover also has benefits for the significant environmental services such areas provide and that are often taken for granted.

Leadership remains an issue. A number of agencies are best suited to providing a lead in the kind of strategic biodiversity planning presented in this work. The Department of Conservation, the Ministry for the Environment and individual regional councils are key to developing and implementing such an approach. Together they represent significant aspects of science and planning, conservation and resource management, and public and private land-use. Their ability to recognise and embrace a strategic approach to biodiversity planning and their willingness to coordinate policy and activities in biodiversity conservation is crucial.

Funding and resourcing meaningful programmes towards strategic biodiversity planning and implementation is essential. An absence of such leadership will result in continuation of the current ad hoc and inconsistent approach to biodiversity protection.

The consequences of not taking such a strategic and comprehensive approach to biodiversity conservation seem almost certain and irreversible. New Zealand's "most pervasive environmental issue" will continue to deteriorate to a critical level… and beyond. The New Zealand Biodiversity Strategy identified a key issue in halting biodiversity decline as,

> *"finding ways to maintain the indigenous biodiversity values of natural habitats and ecosystems outside of protected areas, and to sympathetically manage indigenous biodiversity in production landscapes… Both these tasks involve restoring connections between presently isolated fragments of natural ecosystems."* (p.9)

So far, it seems we have had little success in achieving this. The approach reviewed and demonstrated in this thesis provides a "way" that has a firm theoretical foundation, international precedent, and practical methodology for application. Implementation of such an approach would provide a leap forward in biodiversity conservation for New Zealand and ensure our indigenous biodiversity has a significantly brighter future.

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ACRONYMS (& ABBREVIATIONS)

ANU	Australian National University, Canberra
BAP	Biodiversity Action Plan
BRANCH	Biodiversity Requires Adaptation Under a Changing Climate
BRE	Building Research Establishment Ltd
CHaMPS	Coastal Habitat Management Plans
CIRIA	Construction Industry Research and Information Association
CIWEM	Chartered Institute for Water and Environmental Management
CMS	Conservation Management Strategy
CSIRO	Commonwealth Scientific and Industrial Research Organisation
Defra	Department of the Environment, Food & Rural Affairs
DOC	Department of Conservation
ECONET	European Ecological Network
EU	European Union
GIS	Geographic Information System
GWRC	Greater Wellington Regional Council
GYE	Greater Yellowstone Ecosystem
IUCN	International Union of Conservation and Nature
LCDB	Land Cover Database
LDF	Local Development Framework
LEEP Model	New spatial model for strategic biodiversity conservation planning
LENZ	Land Environments of New Zealand
LPA	Local Planning Authority (UK)
LRC	Local Record Centre (UK)
MAB	Man and Biosphere program
MfE	Ministry for the Environment
MONARCH	Modelling Natural Resource Responses to Climate Change
MUM	Multiple-use Model
NGO	Non-governmental organisation
NPS	National Policy Statement
NZBS	New Zealand Biodiversity Strategy 2000
ODPM	Office of the Deputy Prime Minister
PPS	Planning Policy Strategy (UK)

RAP	Recommended Area for Protection
RMA	Resource Management Act 1991
RPS	Regional Planning Strategy (NZ)
RSS	Regional Spatial Strategy (UK)
SD	Sustainable Development
SLOSS	Single Large or Several Small (habitat patches)
SOE	State of the Environment report
Tb	Tuberculosis
UKBAP	United Kingdom Biodiversity Action Plan
UKCIP	United Kingdom Climate Impact Programme
UNESCO	United Nations Educational, Scientific and Cultural Organisation

APPENDICES

APPENDIX A – WELLINGTON PLANNING DOCUMENT REVIEW

Summary review of biodiversity provisions in Wellington Regional and local authority plans.

A. REGIONAL AUTHORITY DOCUMENTS

Wellington Regional Policy Statement (RPS)

The regional policy statement for the Wellington Region (Wellington Regional Council, 1995) predates the NZBS and many developments in bioregional planning and biodiversity conservation. The Greater Wellington Regional Council is now in the process of reviewing its RPS.

However, the operating RPS recognises the loss of "ecosystems" as one resource management issue for the region and states:

> *"The number, total area and quality of the Region's ecosystems is declining. For example, 90 percent of the wetlands that existed in the Wellington Region as recently as 1840 no longer exist. Now only 1.6 percent of the Region remains in wetlands and few of these areas have any degree of formal protection. Urban demands have had, and continue to have, a significant detrimental impact on such systems, often permanently impairing their ability to function and, therefore, to provide vital services for people. For example, a lack of water in a river system not only damages habitats, but can also reduce a river's capacity to assimilate wastes."*(p.21)

The statement seems to focus on the loss of wetlands, when the loss of indigenous habitat has been just as significant. On a vision for the future, the RPS states the possibilities and includes:

> *"The water in streams, rivers and lakes is of a quality and of sufficient quantity to meet the demands of people and ecosystems. The natural character of wetlands, lakes and rivers is preserved, and there is public access to and along important water bodies."* (p.22)

And continues, to include

> *"The natural and managed ecosystems are healthy and their processes support diverse populations of plants and animals and maintain the quality of soil, air and water."* (p.22)

The RPS policy section contains a section on Ecosystems (Chapter 9 p.151). While recognising other sections (e.g. Fresh water, Soil, but interestingly not Coastal)) also have ecological significance, the policy clearly seas indigenous systems as separate from significantly modified ones, but recognises that, *"Everything is interconnected"* and that ecosystems do not live in isolation from the wider environment (p.152).

Section 9 covers issues, policy, objectives and methods of implementation for Ecosystems of the region. Identified issues are listed in **Table A1.** This shows a clear awareness of ecological issues challenging the Region's biodiversity. The resultant objectives, policies and implementation methods are tabled in **Table A2.**

This was an early attempt at strategic ecological planning. Despite the appearance of a landscape ecological approach to biodiversity planning - with terms such as 'ecosystem approach', corridors', 'buffers' etc – implementation has been very limited after 12 years. This is, perhaps, illustrated by the fact that Regional Plan have been prepared for a number of natural resources in the Wellington region – soil, water, coast – and while these may contain elements of biodiversity acknowledgement and planning, a Regional plan for biodiversity has yet to be undertaken., Senior GWRC staff involved in biodiversity planning have indicated to this author that a comprehensive and strategic approach to biodiversity planning remains difficult. Integration across GWRC activities is poor.

An attempt at preparing a biodiversity plan was eventually abandoned because of strong opposition from local farmers concerned at for potential further erosion of private property rights. (Crisp Pers.comm 2007)

Table A1. Issues recognised in the RPS for ecosystems in the Wellington Region
(Wellington Regional Council, 1995: section 9.2 p. 153-154)

- Issue 1 - the number and total area of indigenous ecosystems has declined
- Issue 2 – The quality of ecosystems is deteriorating
- Issue 3 – The diversity of species is declining (as a result of loss of area and quality of ecosystems)
- Issue 4 – Modified urban and rural ecosystems have not been prioritised for protection and restoration
- Issue 5 – Some special ecosystems are not protected at all, insufficiently protection, or not managed properly
- Issue 6 – Protection and management of remnants on private land is difficult and landowners unaware
- Issue 7 - There is a threat to special ecosystems and their surroundings if only protected areas are managed rather than the wider environment. This is particularly true for small, dispersed remnants. *"Inappropriate developments have been allowed to further fragment and isolate ecosystems"*
- Issue 8 – Introduced plants and animals have caused local extinctions such as mistletoe and northern rata
- Issue 9 – Lack of information about the "*dynamics of the Region's ecosystems… to be able to set environmental bottom lines"*
- Issue 10 – Lack of public and organisational awareness on environmental issues

Table A2: Greater Wellington Regional Council RPS Provisions for Biodiversity Conservation

OBJECTIVES (p.155-157)	**POLICY** (p.157-162)	**IMPLEMENTATION METHOD** (p.162 -170)
Obj.1 – Overall quality of indigenous and modified ecosystems is increased. Characterised by the following criteria: 1. Ecosystem links are intact and functioning 2. Ecosystem processes are functioning properly 3. Non-living components (e.g. soil, water, air) retain their natural characteristics 4. Ecosystems have appropriate high species diversity 5. Ecosystems will be resilient or able to adapt to change and environmental stress **Obj.2** – Healthy, functioning ecosystems are located throughout region. • 94% of pop live in urban areas and undervalue urban ecosystems • Rural ecosystems are undervalued including roadside strips, shrublands & remnant forest • *"Even relatively modified ecosystems can survive as habitats for indigenous species, & can act as buffers & corridors for more significant ecosystems."* **Obj.3** – The area and quality of ecosystems is increased • Area & quality are two important criteria for monitoring the state of the Region's indigenous ecosystems along with Obj.1 criteria • *"The size of an ecosystem has a large impact on its ability to function and the health of its component species."* **Obj.4** – The Region has a diversity of healthy ecosystems representing the full range of regional flora, fauna, and habitats **Obj.5** – Special ecosystems in the Region are actively protected & appropriately managed. Requires two elements: 1. Identify special ecosystems 2. Protect through proper management	**A. <u>Ecosystems Approach</u>** adopted for the management of natural resources (p.157) **Pol.1** - Increase ecosystem understanding **Pol.2** – Increase public awareness of critical ecosystem services **Pol.3** – Integrate ecological principles into planning and operations. *"For an ecosystem approach to be recognised and implemented it requires a fundamental shift in attitude."* **B. <u>Avoid, remedy or mitigate adverse affects on ecosystems</u>.** **Pol.4** – avoid, remedy, or mitigate reduction of ecosystems, interference with ecosystem processes, or "simplification" of ecosystems **C. <u>Restoration & Protection</u>** **Pol.5** – Prioritise ecosystems for restoration and protection: on criteria of threat, representativeness, rare, vulnerable or other special quality **Pol.6** – Restore or enhance degraded indigenous ecosystems or priority urban or rural ecosystems **Pol.7** – Actively protect the same **Pol.8** – Improve management of existing protected ecosystems **Pol.9** – Prevent the isolation of ecosystems by providing linking corridors and buffer zones and avoiding the fragmentation of ecosystems. **Pol.10** – Encourage planting of native vegetation	**A. <u>Ecosystems Approach</u>** **M.1** - Gather information & monitor for: 1. SOE reporting 2. Database establishment of ecosystems & species 3. Include monitoring provisions in RP Encourage inclusion of ecosystem monitoring in DP **M.2** – Resource consent condition to monitor health of ecosystem by consent holder **M.3** – Encourage development of processes for local communities & tangata whenua to monitor health of ecosystems **M.4** – Achieve integrated management through: Statutory Processes; Education; Interpretive centres; Environmental audits; Sponsoring projects; Teaching modules Publications; WRC example setting; Codes of practice; Annual reports; Education centres; Student placement **M.5** – Integrate relevant western & Maori ecological principles in relevant policy & plans **M.6** - integrated management through: a) Interagency liaison b) Coordination of databases & monitoring c) Integration of research results into regional & territorial plans d) Coordinate management of adjacent ecosystems **B. <u>Avoid, remedy or mitigate adverse affects on ecosystems</u>** Methods mentioned elsewhere, plus.. **M.7** – In cooperation with AHB, MAF & DOC control possum and educate landowners on animal pest control **M.8** – DP as appropriate mechanism for implementing **Policy 4** **M.9** – Interagency control of substances & organisms with potential to adversely affect ecosystems using other statutory and non-statutory means

		C. **Restoration & Protection** **M.10** – Prioritise ecosystems in consultation with other agencies **M.11** – Restore & enhance high priority degraded systems when practical **M.12** – Protect indigenous ecosystems & high priority urban & rural ecosystems where practicable **M.13** – Review & improve management of Council lands **M.14** – Support community initiatives for restoration and enhancement of high priority ecosystems **M.15** – Encourage, support & facilitate protection on private land & of significance to iwi by: 1. Acting as info source on options 2. Investigating & coordinating financial & other incentives 3. Flexible approach to formal and informal voluntary protection mechanisms **M.16** – Use of district plans **M.17** – Use of esplanade reserves & strip provisions for protection of riparian ecosystems **M.18** – WRC consultation with other agencies to identify areas where linking corridors & buffer zones are needed & advocate for their establishment & protection **M.19** – DP appropriate means of implementing **Policy 9** **M.20** – Integrated management to achieve **Policy 10**

A number of key issues have arisen (pers.comm. Crisp 2006) in the current review of the Regional Policy Statement relating to biodiversity are:

- performance indicators to be able to assess the effectiveness of any biodiversity protection and enhancement measures
- Whether there should be a separate biodiversity section, or whether elements of protection are spread throughout section on specific natural resources e.g. soil, water, coastal.

The author's own observations of on-the-ground improvements on a region-wide basis suggest outcomes have been limited or non-existent. One observation from my own analysis of the RPS provisions for 'ecology' in the Region is that there was no overall spatial strategy and that there was a very real potential for any attempts at ecological protection and restoration to be small-scale, localised, and piecemeal – which, I believe, has turned out to be the case. I suggest the term ‘ecosystem approach’, has been interpreted on too small a scale, while there was opportunity to provide bigger-picture, region-wide leadership.

Current debate among GWRC staff over the RPS review indicates there is still opportunity for ongoing policy fragmentation. This author believes there is greater scope for a more comprehensive, integrated and strategic lead to be taken on biodiversity planning in the Wellington Region by Greater Wellington Regional Council.

B. LOCAL AUTHORITIES

1. Wellington City Council

District Plan

The current District Plan became operative in 2000. The Open Space section recognises that, *“Many open space areas have conservation values as support or buffer areas for Conservation Sites, and in particular contribute to wildlife corridors. It is envisaged that some will eventually become Conservation Sites.”* (Wellington City Council, 2000:16/1). The Plan makes provision for an ‘Open Space B’ zone recognising areas that are mostly vegetated and often have ecological values or may buffer Conservation Sites.

Open Space objectives include protecting native vegetation cover, re-planting where appropriate (s16.5.2.3, p16/5-6) recognising their potential as wildlife habitat, linking corridors and buffer zones, as well as ecosystem services in soil and water conservation.

Conservation sites are provided for and objectives set to protect them and adjacent activities to minimise impacts on conservation sites (p.18/1).

Outer Green Belt Management Plan

This Plan introduces the concept of an Outer Green Belt and an associated Management Plan (Wellington City Council, 2005) recognising the potential to develop an almost continuous ecological corridor around urban Wellington. The Plan contains a number of maps that attempt to delineate such an outer green belt and a potential network of various ecological corridors.

Environmental Strategy

The Council has recently produced an *Environmental Strategy* (Wellington City Council, 2006). which seeks to provide a high-level statement of the Council's long-term environmental intentions for Wellington, as well as shorter-term priority areas for action and an holistic approach to the management of Wellington's natural environment.

The *Strategy* identifies a lack of a biodiversity plan and the intention to develop one as a priority action. At the time of writing, an inter-agency group (represented by officials from DOC, GWRC, WCC, QEII, MAF) have been meeting to plan a Biodiversity Action Plan for Wellington City and have a draft for public consultation by mid 2007.

Among other issues, the *Strategy* identifies climate change, invasive animal and plant pests, and disturbance of ecosystems, as significant issues confronting the City environment.

While components of these are addressed in some management documents, the *Strategy* identifies the Council lacks an overarching environmental strategy that could explain how the various elements of the natural environment and Council's activities inter-relate, and what the priorities are. In particular, the Council acknowledges a policy gap in the area of biodiversity management.

One of the key action points of the Strategy was to prioritise the development of a biodiversity action plan for Wellington City. An inter-agency group (comprising officials from WCC, GWRC, DOC, MAF & QEII) has already begun developing aspects of a BAP, key community group consultation has begun, and a draft BAP is scheduled for notification in mid 2007.

Urban Catchment Restoration

Recently, the Wellington City Council and the Greater Wellington Regional Council commissioned a report on *"Priorities for Ecological Restoration of the Kaiwharawhara Catchment Wellington City"* (Blaschke et al., 2004). The report was a response to diverse restoration activities in the urban Kaiwharawhara Catchment by several community groups, including the Karori Wildlife Sanctuary and the Otari/Wilton Native Plant Museum. The report was intended to give an oversight of this work and provide an integrated plan for the catchment to guide the community and joint council restoration work within the catchment.

The authors suggest an integrating aim for catchment restoration,

> *"To establish a locally native vegetation canopy within restoration areas appropriate to their environment, and to establish effective linkages between restoration areas."*(Blaschke et al., 2004: Summary and Overview)

They identify three different zones within the catchment and recommend different aims and methods of restoration for each zone:

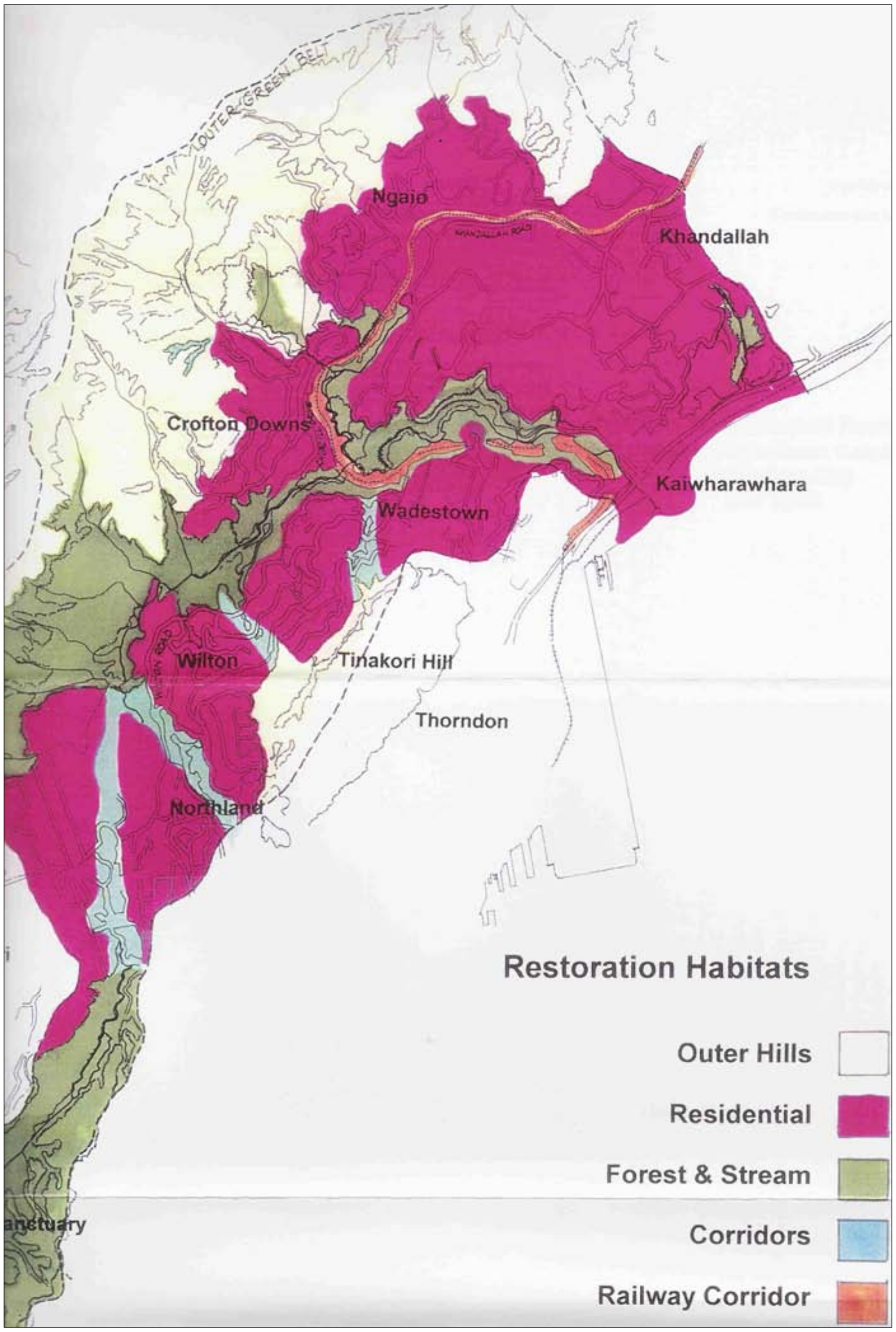
> **Restoration Habitat 1 - Forest & Stream:** "*Ecological management should be aimed at maintaining and enhancing the already generally high environmental quality of these areas, especially and including the riparian habitat and stream biota."*
>
> **Restoration Habitat 2 - Outer Hills**: "*Ecological management should be aimed at allowing regeneration to continue unhindered where possible."*
>
> **Restoration Habitat 3 - Valley Residential:** "*Ecological movement should be primarily through the provision of information, advocacy and suitable native plant material to private owners, focussing especially at the owners in the "corridor habitats" between areas of Forest and Stream and Outer Hills habitat."* (Blaschke et al., 2004: Summary and Overview)

The map of priorities for ecological restoration is given in **Figure A1** and demonstrates the different restoration areas and proposed corridor zones. Points to note about this project:

- The review and recommendations of this report were based on principles from landscape ecology (Pers.comm. Blaschke 2007).
- The restoration of core areas and enhancement of corridors treats the whole catchment as an ecosystem and centres around the stream system, with particular attention to landowners in "corridor habitats". Ecolinks with adjacent catchments and forest areas are recognised.
- Both councils have been active in joint work involving the community in removing instream barriers to fish passage and design and installation of strategically placed interpretive panels on the community/Council restoration work and freshwater ecological restoration.
- This is an urban restoration project affecting peri-urban and residential areas involving partnerships between council's and community groups already undertaking restoration work. The report signals the need to recruit additional community support and involvement in the overall restoration plan through information, advocacy and provision of appropriate plant materials and advice.

- The Councils have signalled their intention to apply a similar partnership approach to ecological restoration involving communities to other catchments in the Wellington City area – Ohariu Valley to the west, and possibly the Kenepuru Stream in the northern area of the City.

Figure A1: Example of a landscape ecology approach applied to the New Zealand urban situation (From Blaschke, Forsythe, & Anstey, 2004).



Biodiversity Action Plan

Wellington City Council has released a draft *Biodiversity Action Plan* (BAP). This is a significant initiative and demonstrates Wellington City is taking a lead in biodiversity conservation in the region. The draft seeks to protect the City's biodiversity resources through a combination of identification, pest control, community education and involvement. While there is tacit mention of the need for ecological corridors, there is still a poor appreciation of the significance of spatial landscape patterns on functional and sustainable ecosystems. Neither does the BAP do much to overcome the setting of regional conservation priorities.

2. Porirua City District Plan

The Plan (Porirua City Council, 1999)became operative in 1999. Section 9 on 'Landscape and Ecology' recognises the very depleted and small remnant nature of native vegetation cover and species within the district. It establishes a 'Landscape Protection Zone' to protect these resources.

It recognises vegetated gullies and other "sensitive ecological areas" as important ecological habitat and links (e.g., Takapuwahia/Elsdon Bush as a link between Whitireia peninsula and Colonial Knob (p.C9-9), Plimmerton, Pukerua Bay, Whitby) and the need to protect them from development. The Plan also recognises the need to protect the "ecological integrity" and processes of the district. However, there seems no provision for restoration or enhancement.

3. City of Lower Hutt District Plan

The City Plan seeks to recognise and protect significant natural areas through restrictions and conditions on resource consent applications on the basis of the following criteria:

- Representativeness
- Rarity
- Diversity
- Distinctiveness
- Continuity and linkage with the landscape
- Cultural significance – to Maori, recreation and landscape interests
- Ecological restoration (capability)
- Landscape integrity
- Sustainability – size and shape, boundary activities, proximity to other protected areas, links, and ease of management

There seems no attempt at any strategic or comprehensive approach to biodiversity conservation planning in the district.

4. Kapiti Coast District Council

The District Plan recognises the protection of indigenous vegetation and habitat. The objectives and policies for Ecology (C.11, p.C.11/1-3) state as the overall objective for the natural environment, to…

> *"Protect and enhance the natural environment and the ecological integrity of the district, including protection of significant indigenous vegetation and significant habitats for indigenous flora and fauna."*

To achieve this objective the Council sets out a number of policies that include

- Identify and protect significant sites of flora and fauna. (POLICY 1)
- Control subdivision and development to protect the natural environment from adverse affects including impacts on water tables of water bodies, disturbance to fauna and habitat, water quality, and treatment of run-off from subdivisions. (POLICY 2, 5, 6, 7, 14)
- Monitor the quality of the natural resources. (POLICY 3)
- Removal and disturbance of indigenous vegetation controlled and avoided or minimised. (POLICY 4)
- Planting of locally sourced indigenous species in areas that will restore linkages and ecological corridors. (POLICY 8)
- Restoration of degraded habitats with locally sourced native vegetation. (POLICY 9)
- Protection of areas identified as suitable for providing linking corridors for fauna. (POLICY 10)
- Buffer zones are provided around areas of significant natural value and that wider ecological processes are considered when making decisions about significant sites. (POLICY 12)

Methods by which these policies will be achieved include:

- Rules and Performance Standards.
- Covenants or consent notices on the title.
- Inclusion of significant ecological sites in the Heritage Register
- Direct purchase.
- Open space zone - river/stream mouths.
- Incentives.
- Community involvement (planting of native trees, including riparian plantings).
- Fencing of forest remnants from stock.
- Education (jointly with other agencies).

The intentions to identify, protect, enhance and restore, where appropriate, core areas, buffers and ecological links shows an awareness of important ecological dynamics and a willingness to protect these ecological resources.

5. Upper Hutt City

The district plan (Upper Hutt City Council, undated) section on 'Landscape and Ecology' (section12, p.12/1) identifies among its natural resource issues,

- *"The destruction of indigenous ecosystems and the subsequent loss of biological diversity."*
- *"Loss of indigenous vegetation and habitats on private land."*

The relevant objective states that,

- *"The protection and enhancement of significant indigenous ecosystems and biological diversity."*

Policies include:

- To protect and enhance significant natural areas of indigenous vegetation and fauna habitats from the adverse effects of activities that would reduce indigenous biological diversity and/or the life supporting capacity of ecosystems. (12.4.1)
- To preserve and enhance the indigenous vegetated southeast ridge from Pinehaven to Te Marua and the northwestern ridge from Keith George Memorial Park to the Akatarawa River to maintain their function as ecological corridors. (12.4.2)
- To protect wetland areas within the City from activities which would have adverse effects on their life supporting capacity, natural character or habitat values. (12.4.3)
- To introduce a Plan Change or Variation as soon as practicable to identify significant natural areas within the City. (12.4.4)

The method by which these will be achieved is:

- Rules to promote the retention of bush-covered hillsides with the provisions of the Conservation Area within the Residential Zone, and standards to implement the landscape and ecology protection policies.12.5.1, p.12/6
- Reserve Management Plans. 12.5.2
- Education programme to increase public knowledge of the existence and importance of ecologically significant sites within Upper Hutt. 12.5.3
- Consultation with potentially affected landowners and occupiers, the tangata whenua, Orongomai Marae Committee, Department of Conservation, Wellington Regional Council, volunteer groups and other interested parties as appropriate. 12.5.4
- Encourage protection of significant natural areas on private land, through recognition of the positive effects of resource consent applications which incorporate measures to protect natural resources. 12.5.5
- Take a precautionary approach in dealing with incomplete information on sites with high natural values and attempt to compile a better understanding of resources over time through appropriate monitoring and research/survey work. 12.5.6
- Provide advice and support to other groups and organisations engaged in the protection and enhancement of biological diversity. 12.5.7
- Introduce a Plan Change or Variation, involving a process of research, consultation and formulation of practical statutory and non-statutory methods, to facilitate the

preservation and enhancement of significant indigenous vegetation and fauna habitats. 12.5 8

6. South Wairarapa – Carterton – Masterton Districts

These three councils cover the Wairarapa Area and share a common Proposed Combined Wairarapa District Plan (Combined Wairarapa Districts, 2006). This plan acknowledges a range of issues in the introduction to Section 11 'Indigenous Biodiversity' and notes that,

> *"The majority of remnant forest and wetlands in the Wairarapa are not being actively managed in a way that would ensure their continued existence and enhancement. Furthermore, the need to recognise and enhance ecological corridors in the Wairarapa is an important an issue, as such links are essential to protecting the sustainable long-term future of indigenous species."* (Section 11. p105 SWDP.)

Specific 'Significant Resource Management Issues' (section 11.2. p.106) listed are,

> ***1***. *Land use, subdivision and development can result in the damage and destruction of habitats, leading to their irreversible loss, further fragmentation, and a reduction in species abundance and biodiversity."*
> ***2***. *Many remnant forests and wetlands require active protection and management in a way to ensure their ongoing long-term continued existence and enhancement."*
> ***3***. *The protection of natural habitats and biodiversity values needs to be balanced with private property rights."*
> ***4.*** *Landowners need support from a range of authorities and agencies for initiatives to protect and maintain biodiversity."*
> ***5***. *Ecological corridors, which are important factors to the ongoing sustainability of biodiversity, are difficult to identify and maintain or enhance*."

Objective Bio.1 for Biological Diversity states that one objective is,

> *"To maintain and enhance the biological diversity of indigenous species and habitats within the Wairarapa".*

And the accompanying policies are to,

- **a.** *Coordinate with other agencies and organisations in identifying risks, requirements, opportunities and effective methods for protecting and enhancing Wairarapa's biodiversity.*
- **b.** *Collaborate with other agencies and organisations in undertaking joint initiatives and in supporting landowners' initiatives in the protection and enhancement of biodiversity.*
- **c.** *Control the further destruction or irreversible modification of areas of indigenous vegetation or habitats where there may be significant biodiversity value.*
- **d.** *Provide for clearance and/or drainage where there is little significant biodiversity value or potential.*
- **e.** *Protect the ecological integrity of areas of indigenous vegetation or habitat of significant biodiversity value.*

f. *Support and encourage the protection of natural habitats on private land, including restoring and protecting linkages and ecological corridors.*
g. *Increase public awareness of the natural values within the Wairarapa, and encourage community support for the protection and conservation of the Wairarapa's biodiversity.*
h. *Restrict the farming of goats near areas of significant indigenous vegetation and significant habitats of indigenous fauna to protect their natural values.*
i. *Avoid, remedy or mitigate the adverse effects to indigenous wildlife and indigenous ecosystems that result from the use, development or subdivision of a site.* (Combined Wairarapa Districts, 2006:106.)

The proposed Plan incorporates an impressive set of methods (p.109-110) to implement biodiversity policies that include,

a. In conjunction with other key organisations, preparation of a Wairarapa Biodiversity Strategy by 2008 to establish goals and a programme of action for identifying and managing natural habitats, methods for enhancing biodiversity, and for prioritising actions for protecting significant natural areas.
b. Environmental standards to limit the potential adverse effects of activities on indigenous vegetation wetlands and habitats with actual or potential value for biodiversity.
c. Through the resource consent process, identify where a wetland or indigenous habitat is significant by using the following criteria:
    i. Representativeness
    ii. Rarity
    iii. Diversity
    iv. Distinctiveness
    v. Continuity
    vi. Cultural Values
    vii. Ecological Restoration
    viii. Landscape Integrity
    ix. Sustainability.
d. Through the resource consent process, assess environmental effects where an activity affects a potentially significant natural area.
e. Conditions on resource consents, including consent notices and covenants on Certificates of Title, to avoid, remedy or mitigate the adverse effects of activities.
f. District Plan Standards on goat farming near significant conservation areas.
g. Information and education on the value of the Wairarapa's biodiversity and its significant natural areas, including the need to consider these values when planning an activity or development.
h. Incentives as appropriate to encourage landowners to protect natural habitats, such as rates relief, support with fencing and pest control, and assistance with applications for protective covenants.
i. Provision to create conservation lots to form separate tenure of natural areas.
j. Financial Contributions, including reserves and works to protect significant natural areas.
k. Information through the Land Information Memorandum process under the Local Government Act 1974 to inform landowners and developers whether an allotment is located within and/or contains a natural area.
l. Use of other statutory functions and powers to promote biodiversity such as the Reserves Act 1977.

m. Cooperation with landowners, organisations, groups and interested parties involved in conservation management.
n. Support for local conservation care groups and programmes.
o. Purchase of significant natural areas where full protection of the area or public access is justifiable.
p. As appropriate, use Heritage Orders to protect specific areas, particularly significant areas under immediate threat.

APPENDIX B – INTERVIEW SUMMARY

A. INTERVIEW QUESTIONS

Interviews were undertaken on an informal basis to allow for expression of the interviewees. However, interview questions revolved around exploring the interviewees' current understanding and appreciation of the following topics, as appropriate:

1. The current perceived state and status of landscape ecology.
2. Climate change and the impacts on landscape planning approaches.
3. Response to draft maps and policy matrix developed for the Wellington Region.

B. OVERSEAS INTERVIEWS

1. **Dr Reed Noss** – Professor of Conservation Biology, University of Central Florida, Orlando, Florida, USA (Email discussion 2 May 2006).

Current status of landscape ecology:

On the corridor debate Reed says, "[The corridor] *debate has fizzled down. Virtually everyone agrees now that connectivity is an important consideration much of the time in reserve design and landscape management, and that corridors are often the best way to achieve connectivity. Much of the interest now is on the issue of how to design corridors (or alternately, a suitable landscape matrix) for particular species or sets of species in particular cases."*

There is now an increasing focus on connectivity and he is contributing a chapter to a (now delayed) book on connectivity from Cambridge Press coming out in summer (Northern hemisphere 2006). His essay for the book that will emerge from the workshop that Denis Saunders and he were attending also focuses on connectivity. A draft chapter was provided to assist research (Noss April 2006. *Focal Species for Determining Connectivity Requirements in Conservation Planning*. Presentation to Conservation Biology workshop in Australia 2006)

2. **Dr. Daniel Simberloff** – Professor of Environmental Science, University of Tennessee, Knoxville, USA (Email discussion 18 May 2006).

Current status of landscape ecology:

On the corridor debate, Simberloff says, *"The [corridor] debate is now more on how much and where, and how to determine these things… and almost everyone feels that in most situations, connectivity at some level is important, but how to achieve it (Corridors, matrix management, or translocations, etc.) is very much up in the air, and very system specific*." He commented that there is a realization that too many things fall under the 'corridor' rubric to give generic laws or recommendations, and there is recognition that this is a problem.

He agrees with Reed Noss' evaluation that the corridor debate has fizzled out and that there is now general acceptance that connectivity is important and the debate is more on how much and where and how to determine these things.

He doesn't think there is a consensus on reserve network design, nor on ecoregional planning, rather he thinks there is generally a view that it can't hurt to think about things from an ecoregional perspective, but there is some worrying among people who work in conservation on the ground that we don't know enough yet about how to achieve that perspective, but we do know enough about how to manage some specific reserves or groups of them.

Reflecting on the lack of uptake in NZ of a landscape ecology approach to reserve network design, and the continued focus in NZ on species and island preserves, he say that except for the Nature Conservancy, there has not been a systematic attempt to use the landscape ecology approach in the USA either.

3. **Dr Andrew Bennett** – Conservation biologist/landscape ecologist and lecturer at School of Forest Conservation at Deakin University. (Interviewed 1 June 2006 at Deakin University, Melbourne, Australia with follow up email discussion 5 September 2006).

Current status of landscape ecology:

He considers landscape ecology is the cutting edge of conservation biology and biodiversity planning, and that Richard Forman's work are still the best texts on the subject (Forman, 1995; Forman & Godron, 1986; Forman et al., 2003).

He considers one of the keys to achieving better biodiversity outcomes is translating the science into the community and action. Top-down and bottom up conservation involvement are both required. He believes that the entry point for this translation is linking into human need though a focus on the environmental services that reserves and remnants provide. He believes these services should be used as a means of promotion, maintenance or protection of biodiversity and habitat.

Originally a strong advocate for corridors and author of report for the IUCN on ecolinkages (A. F. Bennett, 2003), he is now concerned more with the configuration of remnant patches following his research that suggests that remnant coverage and configuration is more important than simply corridors. Stepping stone patches may be more critical than corridors in certain situations. Certainly that continuous corridors for corridors sakes may be a waste of resources compared to increasing the size and number of remnants (Radford et al., 2004). This research suggests that 10% indigenous coverage is a critical point for the maintenance, restoration and repopulation of remnant forest. He believes that his work on remnant coverage is relevant to the New Zealand situation because it is based on birdlife – a dominant part of the New Zealand wildlife context – but adjusted for the New Zealand conditions relating to the existence of introduced mammalian predators. He suggests that connectivity at different scales may work better for some species than for others. He still supports corridors as a conservation tool, particularly for less mobile species. He would agree that a continuous connection of habitat is going to be best as their capacity to cross unfavourable terrain will be low. He says this is encompassed in the idea of what is functional for the species of concern. There may be a particular physical structure, but how well and to what extent it can be used depends on the taxon, their behaviour, scale of movement, habitat use etc.

The trend seems to be that the pattern of vegetation, whether scattered or aggregated, has its greatest influence on the birds at low vegetation cover (below about 15%). For species richness of woodland birds, the trend is that as the cover in the landscape decreases, the decline in woodland birds is slower in landscapes in which the vegetation is aggregated into one or a few large blocks compared with those in which it is widely dispersed through the landscape. At higher levels of tree cover this seems to matter less. For individual species of birds, again it was the total extent of vegetation that had influence on the greatest number of species but pattern of vegetation is important for some species.

4. **Dr. Richard Forman** – Professor of Landscape Ecology, Harvard University, Boston, USA (Interviewed 20 November 2006 at ANU, Canberra while on sabbatical leave).

Current status of landscape ecology:

Forman observes that the first 20 years development of landscape ecology is widely used and spreading into more disciplines including ecology, forestry, conservation biology and landscape architecture. Its use is still growing in transport and urban planning, but not too much in agricultural planning yet. Its greatest use at the moment is in underpinning planning and management in addition to its own science. He believes that its strengths are: 1) that it provides a set of principles that can be used over large areas or whole landscapes that we did not have prior to the early 1980s, and instead looked at localised habitats and analysed them in isolation as if regions are homogeneous, which they are not; and 2) that it can accommodate and integrate multi-sectoral interests and the interests of a wide variety of disciplines which it treats as all being important.

Its weaknesses are a lack dialogue with the social sciences and socio-economic disciplines which are traditionally anthropocentrically oriented to find compatibility with landscape ecology which is oriented towards natural systems. There needs to be synergies where planning can occur in an intelligent way for the likes of transportation, economic development, housing, and employment as well as water supply, biodiversity, recreation

He has experienced very little resistance to the application of landscape ecology principles from traditional planning. Forman believes this is because it has insufficient profile to create a 'threat' and therefore any dialogue. Commenting on this further, he says, that because landscape ecology is so spatially oriented, politicians, planners, managers and other decision-makers like it. "It's a map and everyone is able to speak the same language. There is no *hocus pocus* in it. You don't have to have faith in it, you just have to understand it." Another reason he hasn't experienced resistance to landscape ecology is that he is generally dealing with thinkers and planners who want to solve problems. People who are open to new ideas and landscape ecology is such a strong meshing of science and spatial patterns which are universal idea, that it provides a 'handle' that people and decision-makers can get hold of. *"For a planner or policy maker it has to be simple enough to understand it, be able to explain it, and* *to be able to defend it against a hostile audience. It deals with situations such as species against developments but puts it in a framework that is not 'us and them' and avoids a conflict situation from the beginning… The metaphor of a spatial arrangement is a handle for decision-makers to make wise decisions. Using a spatial plan, you can simply change the pattern and if you think about the pattern in advance you can make a better spatial pattern or mitigate the ones that are there."*

Discussion about translating the science into action, Forman cited many positive examples where the principles of landscape ecology are currently being applied or becoming increasingly popular. These include:

- The Greater Barcelona Project – which he considers one of the most ambitious – the mayor and planners were tired of approving development plans piecemeal and wanted a bigger and longer-term picture to defend against other plans and pressures that they considered were just 'wasting land', creating unwanted urban sprawl and affecting important resources such as aquifers that they wanted to protect while directing development. The objective was focused on natural systems and hidden resources of natural systems that affected the long-term economics and tourism in the region. His plan includes covering natural aquifers with vegetation to protect them, protect tourist sites and wetlands etc that were considered as having economic values. In the process his plan also joins six national parks with corridors/walkways, establish 'cultural parks' for important historical market gardening areas. Forman R.T.T. (2006) *Mosaico Territorial para la Region Metropolitana de Barcelona.*
- Western wheatbelt of Western Australia – an agrarian landscape where wheat production and woodland revegetation are successfully occurring based on remnant woodlands and roadside planting in partnership with landcare groups (D. A. Saunders & Hobbs, 1991; D. A. Saunders, Hobbs, & Ehrlich, 1993). Revegetation is taking place to primarily overcome salt leaching and promote biodiversity.
- Netherlands Ecological Network where the government approached Paul Opdam *et al.* to help increase the sparse woodland remnants by at least 10%. In response to the question where and in what arrangement new forest should be planted, Opdam recommended establishment of large patches around existing small patches rather than on bare areas. The idea was that birds were more likely to colonise large patches adjacent to or surrounding small patches, than patches planted in isolation.

- The USA Forest Service work in Minnesota/Wisconsin/Michigan where rather than selecting the cutting programme stand by stand, they took a whole landscape view and considered the effect for not just forest products but also water, soil erosion, fish, wildlife, recreation and road construction and indirectly for the economics. So instead of a traditional patch approach, it was a landscape approach.
- The Pacific Northwest where traditional dispersed-patch cutting was abandoned in favour of more environmentally-friendly methods following evaluation using a landscape ecological approach.
- Road networks fragment the landscape and affects water, erosion and sedimentation. *Roading Ecology* (Forman et al., 2003) has been selling well in USA and overseas as the first book dealing with roading networks and their impacts. Research has established that interior forest birds stay back from busy roads several hundred metres and even kilometres from very bus highways. In the USA, *"Traffic has been growing and its affect has been widening."* He suggests that if you want to protect interior forest birds in through use of a nature reserve, you shouldn't do that near a major highway. Though there is limited data, Forman says that it seems unlikely that the cause of this native species void adjacent to highways is due to invasive animal and plant species accessing forest from these highways. He believes that the most probable way that seeds and plants get to park and recreation lands is through the contaminated vehicles and clothing of people from exotic-dominated urban areas, rather than from highways themselves.

Shown the expanded diagrams and rules for reserve network design principles, Forman was comfortable with the new summary/drawings of principles of landscape ecology as a development of Diamond (Diamond & May, 1976), noting however that these diagrams represent an 'ideal' world, and we don't live in an ideal world. So while the diagrams are useful generalisations they are also 'academic', particularly the climate change north/south alignment of reserve networks where achieving this may be a luxury or not at all possible.

On corridors he comments that, *"While a few 'nay-sayers' remain, overall ecologists and planners note that the major benefits of natural corridors overwhelms any minor shortcomings."* Further, he also makes the point that some of the most important landscape types are dominated by corridors (Forman, 1991: 71) and that from a biodiversity conservation perspective, it is very hard to dismiss corridors as a significant tool in accomplishing sustainable and effective ecological outcomes.

However, he believes there is no point in addressing corridors unless what he calls "large green blobs" (i.e. core areas) exist and these large blobs are protected. Further on corridors and stepping stone patches, he referred to *Land Mosaics* (Forman, 1995) in which he prefers clusters of stepping stones as a better strategy rather than rows. This provides 'alternative routes' for species such as birds if there is a threat in one patch and provides more stability in climate change than a strip. Also, in his experience it is very hard to protect a corridor – there is always one land owner who doesn't.

On isolated paddock tree remnants, he recognises that the people at ANU – Lindenmayer and Manning – are 'big' on individual old, large remnant trees because they have holes and other habitat important to multiple species. He is less convinced. If you compare a younger isolated tree to an older larger one then there are merits in the older tree. But if you compare an isolated older tree to a patch of ones of the same age, then there is a fundamental difference, unless you want to use the isolated one as a stepping stone. However, the isolated tree could be legitimately used, as in the Netherlands, as a centre for establishing a new patch. He believes Manning and Andrew Bennett would agree with that. The experience of Lindenmayer shows that revegetation and colonisation of new patches occurs much better around solitary remnant trees than without such trees – so, Lindenmayer is using solitary trees as a nucleus for revegetation.

<u>Climate change and biodiversity</u>:

Forman believes that the north/south alignment of reserve networks as a response to climate change to allow for migration and adaptation may be a luxury or not at all possible simply because of the physical or land cover limitations. There is evidence from Costa Rica which suggests the validity of the 'up/down' altitude dynamics and the wisdom of providing for "vertical migrants" adapting to climate change. He made the observation that most of the species in the Rocky Mountains are vertical migration species that move up and down with the seasons. He has some reservations about constructing vertical corridors because he considers the greatest threat to species is the valleys where human activities and homes pose the greatest danger. So, you need to focus on making the valleys safe for species, including setting aside valleys where human activity is excluded or minimised. But he doesn't know of a lot of people who are busy designating "vertical strips", but wonders whether we should be.

He recognises that sea level rise "certainly has big implications for coastal areas." If the kind of 21ft rise that Al Gore in '*An Inconvenient Truth'* talks about happens, then large currently populated areas are going to be uninhabitable and will cause a large displacement of humans and human settlements - a huge movement of people that will be far more important than the siting of reserves to provide for wildlife movement.

He believes the best protection for biodiversity and buffer against climate changes are "large green blobs" – the perimeter/area ratio is easier to defend in large blobs than in a lot of little "blobs" and corridors. There is no point in addressing corridors until large blobs are part of the landscape and protected. He believes that large green blobs are more likely to survive climate change than many corridors, especially if the corridors are small. However, he would not put all his eggs in "one blob" and that we should ensure we "spread the risk". He suggests we need to plan for between two to five large blobs and then do the risk analysis for two through to having five. But he suggests that if your habitat types are similar you can get away with two or three. But if the habitat types are different, it should be closer to four to five blobs.

We also have to accept that some species may become extinct. He referred to the reality of the Costa Rican example where biodiversity needs come second to human needs when human systems are put under stress.

<u>Application of landscape ecology to Wellington region</u>:

Forman's response to being shown draft ecological network and strategic biodiversity maps of the Wellington Region:

- Admitted he was not familiar with the region
- Saw the axial range forest as both large green blobs and corridors.
- Encouraged by the scale and scope of the area and the intentions;
- favoured starting with a landscape map for the whole of New Zealand and doing the same exercise at the national scale
- Liked the concept of corridor linkages especially that suggested connecting the Rimutaka with the Haurangi Forest Park.
- Agreed with identifying the unique and significant features such as Lake Wairarapa, cities, big patches and main river corridors and investigate how the arable matrix effects patches and vice versa.
- Consider climate impacts – particularly the impact of a wetter west and a drier east.

- He would concentrate making the significant patches bigger

5. **Dr. Adrian Manning** – Post-doctoral Fellow in Landscape Ecology, Centre for Resource and Environmental Studies, Australian National University, Canberra, Australia (Interviewed 21 November 2006 at ANU, Canberra).

Current status of landscape ecology:
He is a New Zealander and one of John Craig's students so he is aware of the low profile of landscape ecology in New Zealand. He is working in the field of landscape and restoration ecology. He suggests raising the profile of landscape ecology through a number of ways:

- Mimic his co-authoring of papers for New Zealand on landscape ecology using respected overseas names such as Forman and Lindenmayer
- Set-up a symposium/conference on landscape ecology using overseas speakers to give some of the keynote addresses
- Create a dialogue on landscape ecology in New Zealand and especially on the impacts of climate change on biodiversity.

6. **Dr. Denis Saunders** – ex CSIRO conservation ecologist and author and President of WWF Australia-in-waiting (Telephone interview 13 March 2006 and interviewed 22 November 2006 at his home in Canberra)

Current status of landscape ecology:
Denis has expressed reservations about connectivity and particularly corridors, because while they may be applicable in certain situations and in certain countries, that there should not be any universal application. Each country is different, like New Zealand where he appreciates the difficulty of our mammalian pests using corridors for instance.

He is sceptical about the Wildlands Project in North America, because he believes they are trying to remove humans from the landscape rather than accepting them as part of that landscape. He believes we have a similar situation in NZ with National Parks & DOC… who still don't accept that humans should be part of the conservation equation and DOC accept the cultural landscape.

He believes that the most significant barriers to addressing reconnecting the indigenous landscape and taking a strategic comprehensive approach to conservation/bioregional planning are in fact sociological and political, rather than ecological – worldwide. In New Zealand, he believes that DOC is still in a traditional mode of thinking with conservation planning that does not even contemplate a change or broadening of its goals and practice to include modern bioregional planning opportunities and accepting the cultural landscape, or interacting with the public whose natural heritage it is. He agreed that DOC really doesn't have great people/sociological skills and demonstrated by the "DOC knows best" attitude shown with the situation that arose about kiore, Maori rat. He believes that it's going to take another generation of DOC managers and informed public to implement any meaningful bioregional planning. Denis concurred with John Craig regards the state of landscape ecology and DOC in New Zealand in that there is a large specialised species inertia to overcome, plus there is the issue of resourcing.

Denis was about to meet with 30 conservation biologists from around the world – including Reed Noss, Hobbs, Larry Harris, Foreman, etc. He also keeps in touch with Michael Soule and others. One of the ongoing focuses is on the application of principles of landscape ecology.

<u>Application of landscape ecology to Wellington region</u>:
Shown the maps of Wellington region, Saunders was positive about the general layout and content of the maps and matrix. He commented that there was the need to <u>cost</u> any suggested biodiversity conservation programme, and that that should be done by a resource accountant (e.g. Ross Cullen at Lincoln University). He is particularly concerned about the implication of the map for the loss of productive land from implied tree planting and the purchase of land to accomplish restoration or protection. He supported the possibility of carbon credit funding paying for all or part of such programmes.

C. ENGLISH BIODIVERSITY PLANNING SECIALISTS

7. **Laurence Tricker** – Project Manager Natural Environment, Kent County Council, England (Email discussion 21-22 September 2006)

Current status of landscape ecology:

Tricker's work in opportunity mapping in England is an example of seeking ways to apply principles from landscape ecology to land-use planning to achieve better and more sustainable biodiversity conservation outcomes. He contributed to an English Nature survey of opportunity mapping practice within (G. Saunders & Parfitt, 2005), which is a record of current activity. The report is meant to give an appreciation of different methodologies and provide a national direction on broad good practice approaches to opportunity mapping. He noted that not all approaches have a credible scientific base (such as the SW rebuilding biodiversity project) and should be viewed with extreme caution. The work by Catchpole (2006) represents the position of English Nature's on ecoregional planning, otherwise known in England as opportunity mapping, and ecological networks. He notes that while the UK is a "devolved country', the ecological network approach is common across the entire UK.

He believes that had Roger Catchpole's work been done 5 years earlier it would have harnessed all local efforts under a more consistent approach. As it is, there is currently no consistent approach to opportunity mapping across England. This results in variable application and outcomes and cross boundary incompatibilities. Data gathering, recording and sharing is another problem. Absence of a nationally consistent and applied data capture on the habitat resource, because no-one seems to have presented the argument to those that have the purse strings that we need a national record of all our habitats, has resulted in locally produced data for local needs based on local resources. He laments the lack of any such data base that is established and maintained at a national level for local application for planners such as himself.

On the issue of corridors and Catchpole's seeming dismissal of them, Tricker commented that in the UK corridors versus a permeable landscape seems to be the issue. He believes that while corridors are a good idea in principle, much of the UK delivery is through agri-environment schemes which are landscape area based and pay little if any reference to creating corridors. So given the unknown needs of so many species Tricker would prefer to try and make all the countryside that little bit better...so a permeable landscape is his preference, not withstanding this, he thinks they need to be adaptive, creative, responsive and opportunistic if they are to safe guard biodiversity and stop decline by 2010.

Tricker observes, however, that there are insufficient resources to meet government 4-year biodiversity targets in a country where, he says, biodiversity has been in decline since the middle ages. He believes the corridor and landscape approach would be the sensible / pragmatic response if there were more time and resources – but they have neither. He notes another problem is that the agri-environment schemes are only for 10 years, which provides no longer certainty on sustainable biodiversity outcomes.

Tricker has visited Holland where they have a national network of 'robust' ecological corridors set out in a master plan that is delivered through: 1) compulsory purchase; 2) when it comes on the market buy it; 3) mitigation or end of use, e.g. quarrying within river corridors for gravels; and 4) agri-schemes that are (he thinks) some 15+ 20 years plus. But he recognises that Holland is a country where the land use was/is so intensive that for wildlife to have any chance they have to establish these types of connections, they are also progressing the greater debate on rewilding large areas and attempting to establish natural state reserves.

Climate change and biodiversity:

Part of his work has included ways to identify impacts of predicted climate change and sea-level rise on biodiversity and how to plan or allow adaptation to those changes. He comments that the UK is heavily committed to addressing climate change as part of its strategic planning. Part of this is seeing to identify and mitigate impacts on habitats and biodiversity. He provides a warning, however, on climate change research in the UK, such as MONARCH. There is still large uncertainty about actual sea-level and climate change projections. Therefore, he considers representations are speculative and practically meaningless. Therefore, the take home message from projects like BRANCH and MONARCH are that it can only be used to provide very broad signposts. His own view is that we should not seek to determine site-specific impacts through such methods. He notes that climate work is being driven by land managers and policy makers who don't take the time to understand the science and want answers to unanswerable questions. He believes that focussing on ecosystem resilience would be more sensible.

He has been involved in the Kent Land Information System (LIS) (www.kent.gov.uk/klis) which he says takes account of the basic climate change principles on habitats in relation to better connectivity, bigger blocks......it's more a problem of management e.g. winter water levels, reduced grazing pressure.

8. **Dr Roger Catchpole** - Senior Spatial Ecologist, English Nature (now Natural England) (Email discussions 22 September and 31 October 2006)

Current status of landscape ecology:
Catchpole is more optimistic and disagrees with Tricker, considering that England does have nationally consistent data in the form of habitat inventories, aerial photography and satellite derived land cover which is the best available information at larger scales. They also have a national initiative to capture species records, called the National Biodiversity Network. Although these sources are not perfect and there are a minority of local areas, such as Kent, that have invested in creating their own information, this is all they have and they need to make use of it. He believes it's always easier to say more information is needed rather than work with what is available! There is a rolling programme of revision that will improve the quality of this data over time.

On the lack of detail on biodiversity in some Regional Spatial Strategy (RSS), Catchpole comments that this is due to the nature of these documents. He says they are intended to be strategic, objective setting documents. They all have extremely limited environmental sections that typically require a single map for biodiversity delivery. Detail is not what they are about.
He suggests the scale where a more detailed approach is necessary is the Local Development Framework (LDF) level. His work is focussed on getting landscape ecology embedded into these documents and other initiatives such as Green Infrastructure. At the moment socio-economic objectives drive the latter while the former doesn't seem to have any clear focus, in spite of PPS9. Some have even been rejected by Planning Inspectors. The key is information provision through which he hopes to bring some influence to bear. He considers they have everything to play for at the moment in gaining effective and sustainable biodiversity outcomes. He points to his own report for English Nature (Catchpole, 2006) as a constructive and workable approach to biodiversity conservation planning consistency.

D. NEW ZEALAND INTERVIEWS

9. **Dr. John Craig** - Professor of Environmental Management, Auckland University (Email discussion 28 October & 7 December 2007).

Current status of landscape ecology:

John agreed with the summation that here in New Zealand we are backward in the area of recognising and applying a landscape ecological approach. He believes a key part of the New Zealand approach is a complete lack of vision. He thought the best approximation might be catchment plans. He noted that roadsides in NZ, with the possible exception of motorways, appear especially devoid of native biodiversity as there appears to be an obsession with grass. Motorways are a possible exception.

Referring to DOC, he believes that a national bureaucracy is unlikely to be innovative or forward thinking. Given that DOC is exempt from the RMA & Commerce Act they hardly need to be nimble, and also as a monopoly why do something different. He believes that a key to resolving this is somehow changing the political view first.

10. **Dr. Philip Simpson** – ex DOC botanist and ecologist, author of *Ecological Restoration in the Wellington Conservancy* (Simpson, 1997) based in Nelson. (Interviewed 12 January 2007 at home Pohara Beach, Golden Bay and follow up email discussion 15 January 2007).

Current status of landscape ecology:

Simpson still stands by the content and recommendations of his *Ecological Restoration in the Wellington Conservancy* (Simpson, 1997). He recalls the first meeting he went to of the Science and Research Directorate when DOC was established in 1987. The first message was about landscape ecology as the way for DOC to go forward. But, obviously, the message was ignored and landscape ecology approach was never implemented. The key person was Geoff Park who called in Philip and Kevin Jones (Archaeologist kljones@doc.govt.nz) to assist with their perspectives. The seminar was primarily for Science and Research staff but and anyone else from DOC or elsewhere were welcome, though Philip not sure if outsiders were there. Richard Sadlier was Director at the time. The issue was how to integrate the many new interests now present under one roof in the Science and Research Division and in particular whether the species-based focus should continue.

He made an interesting point that water and soil conservation plans and catchment plans were primarily interested in curbing erosion, increasing water quality and reducing flooding – not ecological restoration.

Application of landscape ecology to Wellington region:
Simpson was excited by and supported the ecological network and strategic spatial map. He appreciates them as 'not new' being a development of and entirely consistent with his DOC report (Simpson, 1997). He is particularly passionate, however, to move beyond ideas and spatial policy to see application on the ground. He believes the two keys for implementation are translation into farm plans and the funding for this and the strategic planning programme. He sees that partnerships with sectoral interests is crucial.

11. **Dr. Colin Ogle** – ex DOC botanist and author of "An Overview of Reserve Design and Location in New Zealand" based in Wanganui (Ogle, 1989) (Interviewed 19 January 2007 at home in Wanganui).

Current status of landscape ecology:
Colin laments poor uptake in New Zealand of a landscape ecology approach to biodiversity conservation. He and the Conservancy Planner (Jeff Mitchell-Anyon) tried to get landscape ecological principles included in the CMS without success. He is sceptical about my ability to get this kind of approach recognised and included in CMS and implemented. He had also done much work on ecological districts and restoration that was rejected and ecological districts discarded as a management tools.

Application of landscape ecology to Wellington region:
Colin supports the research and maps but made the point that it is 'not new'. He thinks the idea of reconnecting Haurangi and Rimutaka with shelterbelts, roadside planting and landscape matrix is a good one. He also agrees that urban areas should be conservation areas and that such area need more not less conservation as suggested by the maps. He would like to see me develop an example of a smaller scale strategic plan – perhaps of an

Haurangi/Rimutaka corridor. He was interested in the work by Blaschke et.al (2004) in developing a restoration plan for the Kaiwharawhara catchment within the Wellington urban area. He pointed out that biodiversity at Pukerua Bay and the Taupo Swamp must have increased and warrants recognition and placement in any regional strategic plan. He was also interested in the work of Manning et.al (2006) on the significance of small remnants in modified landscapes that suggested they are significant centres for restoration and as stepping stones.

12. **Dr. Geoff Park** – ex-DOC botanist and ecologist, now conservation historian and author based in Wellington (Interviewed in the National Library of New Zealand, Wellington 21 March 2007).

<u>Current status of landscape ecology</u>:

Geoff is excited by this new research. He would change nothing in his report '*New Zealand as Ecosystems'* (2000) and believes little has changed in DOC since he wrote that report. Neither did he believe anything had changed in MfE since he produced his technical paper for them on '*Ecological Integrity'* (1998). Believes that while landscape ecology has so far had little uptake in New Zealand, "its day will come", but has not arrived yet. Maybe we are at the cusp and this research is part of pushing NZ towards that cusp.

<u>Application of landscape ecology to Wellington region</u>:

He is encouraged by and very encouraging of the work and believes it is an important illustration for conservation planner and managers of what the future will look like. The maps are consistent with his own work and thoughts on the need for a more strategic approach to conservation and ecosystem management in New Zealand. He has a crib in the lower Wairarapa Plains and has observed *kereru* (native wood pigeon) flying between Haurangi and Rimutaka Forest Parks that suggests these and the movement of other native species could be facilitated by developing an ecolinkage.

13. **Dr. Colin Miskelly** (Senior Technical Officer, DOC Wellington Conservancy) and **Jeff Flavell** (Community Relations Manager, DOC Wellington Conservancy) (Interviewed together 20 April 2007 at Wellington Conservancy Office).

Current status of landscape ecology:

In relation to the CMS, they conceded that still little is known about the biodiversity resources of the region. They agreed that the ecosystem/landscape ecology approach promoted in the current Wellington Conservancy CMS had not been implemented. They observed from their own experience that the first generation CMS were not ‘sized’, instead they reflected a set of “desirable outcomes” for which there was never enough funding. They were also produced in isolation with no national, top-down direction. This lack of national guidance and absence of national priorities resulted in CMS focusing on local priorities.

They believe that DOC does now have national policies and models for national priorities, so that the next round of CMS will reflect this and be ‘smaller and leaner’. Part of this will be the guidance provided by recently developed NINH (National Inventory of Natural Heritage) framework. There will be greater emphasis on community involvement in conservation. Original CMS were a true reflection of conservation values but now it’s a case of implementation. However, DOC is likely to retrench into priority sites unless there is additional funding. Connectivity is still very important but DOC is likely to be heading away from this and concentrate on priority sites while depending on the community to fill the gaps. (Note: At a subsequent meeting this was confirmed and it became clear that the new generation of CMS will still not take the kind of strategic approach provided by landscape ecology and demonstrated by my maps).

Application of landscape ecology to Wellington region:

Both were interested and very supportive of the maps and their potential applications - particularly providing a basis for investigating and setting priority restoration and corridor areas, especially the Haurangi/Rimutaka ecolink. Miskelly was particularly interested in the potential for using the maps to generate tradable carbon credits, provide an incentive for revegetation and fund eco-restoration projects.

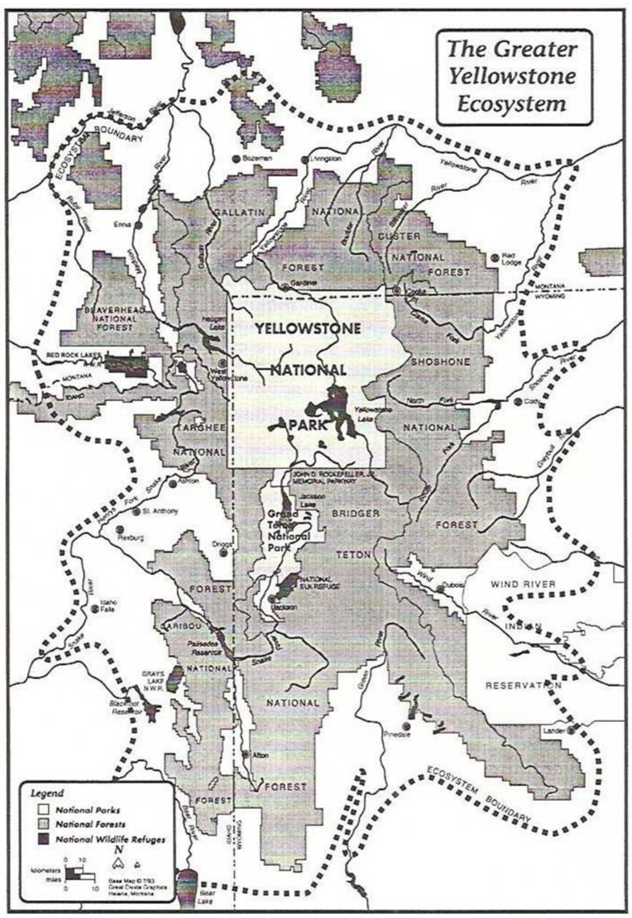
APPENDIX C – LANDSCAPE ECOLOGY SUPPLEMENTARY LITERATURE REVIEW

This *work* provides the full background to the literature review summarised in **Section 2.2.2** of the main text. It supplies important detail on the development and thinking behind current theory and practice in landscape ecology.

A. RESERVE BOUNDARIES

Traditional reserve design throughout the world was not based in science or habitat or ecosystem protection. The original National Parks in North America - which formed a blueprint for nature reserves and parks in many countries such as New Zealand - were created to protect scenery and other natural objectives for public enjoyment. This approach to 'reserve protection' produced unnatural reserve shapes. Many reserves and national parks are predominantly straight and their 'corners' square. Few reflect catchment boundaries or other physiographic or biogeographic features that we know today define natural regions. Many reserves are also too small to maintain larger species or functional ecosystems (Nelson, 1993; Noss, 1990; Noss & Cooperrider, 1994:132). Boundary issues formed one of the first challenges in the development of more scientifically-based and sustainable reserve design (Dasmann, 1988).

Figure C1. Yellowstone National Park and the Greater Yellowstone Ecosystem - An example of incongruous reserve boundaries (Noss & Cooperrider, 1994:135)



For example, Yellowstone National Park is the world's oldest national park and has become a well-documented example of poor historic reserve design typifying the challenges facing biodiversity conservation in the 21st century (**Figure C1**). While the natural diversity of species in the Park is considered intact, its wildness and biodiversity are considered at risk. The Park is now known to be only 12 to16% of the area necessary for maintaining viable populations of key species such as grizzly bear (Noss & Cooperrider, 1994:134).

The size of Yellowstone National Park would be less of an issue if surrounding land were managed in an ecologically sound manner. However, several agencies manage the Greater Yellowstone Ecosystem (GYE) and each has a different management regime, but biodiversity conservation is not a major concern for most of these agencies (Noss & Cooperrider, 1994:136). Heavy clearcutting occurs right to the Park boundary in several adjacent forests as shown in **Figure C2**. Although Yellowstone has been designated a biosphere reserve, management of the GYE remains largely uncoordinated and natural systems unprotected (Noss & Cooperrider, 1994:138). The significance of this North American example of incongruous reserve boundaries is that the Yellowstone model was adopted by many other countries, including New Zealand, along with its inherent problems – inadequate size and shape, reserve isolation, and poor boundary management and biodiversity conservation limited to publicly protected lands. Conservation managers and researchers are now acutely aware of this.

Figure C2. Reserve boundary problems – Yellowstone National Park (left) with national forest clearcutting (right) up to the Park boundary (Noss & Cooperrider, 1994:137)

> *"Isolated parks will not work, nor will multiple-use management that degrades natural qualities… Identifying ecologically functional regions on the basis of physiography, hydrology, species distribution, population viability, migration routes, watersheds, vegetation patterns, fire regimes, patch dynamics, and other natural criteria is imperative. Then those regions must be managed to perpetuate ecological processes and biodiversity."*(Noss & Cooperrider, 1994:138)

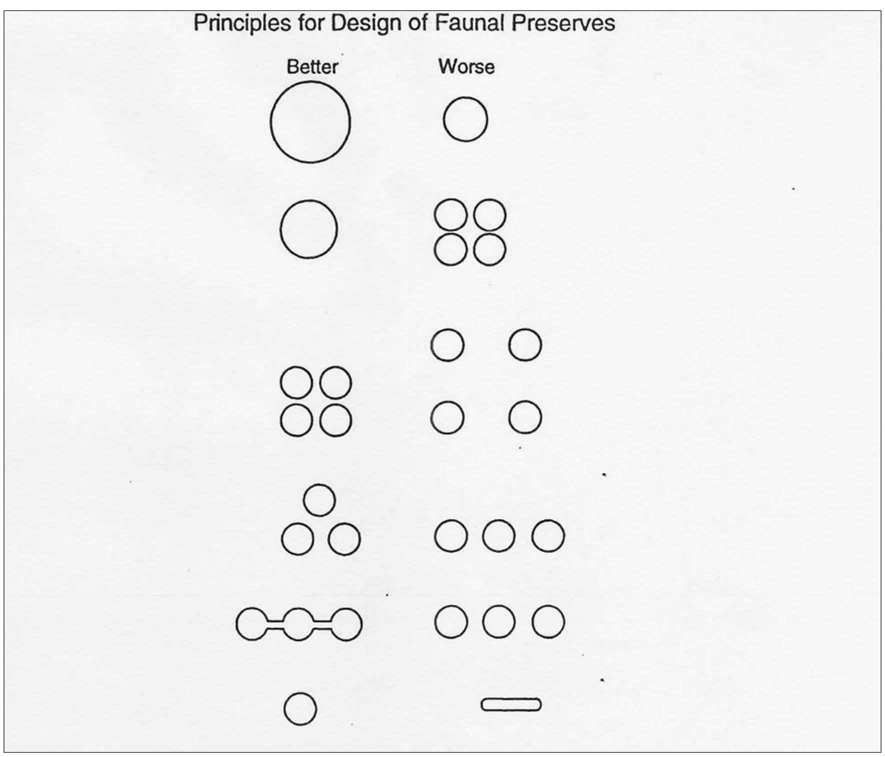
B. SIZE AND PROXIMITY – ISLAND BIOGEOGRAPHY

Modern conservation thought and application of conservation biology and landscape ecology began with the work of MacArthur and Wilson (1963; 1967). Their equilibrium theory of island biogeography considered species diversity on an island represented a balance between immigration and extinction. They predicted that large islands close to a source of colonists would have the highest levels of biodiversity. This led to a challenge to traditional approaches in conservation science in the 1970s, and strengthened the biological basis for reserve design (Noss & Cooperrider, 1994:138).

Critical studies by Terborgh (1974) and particularly Diamond (1975), drew the analogy between MacArthur & Wilson's 'real' islands and that of terrestrial habitat patches isolated by development of the surrounding landscape. Significantly, they concluded and predicted that small isolated habitat patches will lose species. Subsequent evidence began to accumulate confirming this prediction (Noss & Cooperrider, 1994:138).

Drawing further from island biogeographic theory, several ecologists (Particularly Diamond, 1975; but also Diamond & May, 1976; Terborgh, 1974; Wilson & Willis, 1975) proposed rules for the design of nature reserves and reproduced in **Figure C3**. These rules were later included in the World Conservation Strategy (IUCN, 1980), ensuring they received international attention, but not early universal acceptance or application.

Figure C3. Principles for the design of nature reserves, from Diamond (1975). For each comparison, the design on the left is considered better for maintaining species diversity than the design on the right



These rules summarised by Noss and Cooperrider (1994:139) state that:

1. Large reserves are better than small reserves.
2. A single large reserve is better than a group of small ones of equivalent total area.
3. Reserves close together are better than reserves far apart.
4. Round reserves are better than long, thin ones.
5. Reserves clustered compactly are better than reserves in a line.
6. Reserves connected by corridors are better than unconnected reserves.

A number of scientists immediately challenged the rules as premature (D.S. Simberloff & Abele, 1976, 1982, 1991), and also justified their misgivings on the lack of empirical data for island biogeography, problems with MacArthur and Wilson's theory, and the perceived dangers of extrapolating concepts from real islands to habitat islands. Attention was drawn to some situations where several small reserves are preferable to a single large reserve where they contain more species than a large reserve.

Noss and Cooperrider (1994:140) defend the six rules, arguing that although the rules are not based on empirical evidence they were based on collective field experience, biological intuition and island biogeographic theory.

Rule Two was particularly controversial: That a single large reserve was better than several small ones of similar total size. The debate became known by the acronym SLOSS (single large or several small) and claimed to generate more literature than any other topic the history of applied ecology (Noss & Cooperrider, 1994:140). Those scientists arguing for small reserves tended to study insects or plants, while those that argued for large reserves tended to study birds and mammals. *"Vertebrates, especially large-bodied species, are less likely than insects or plants to maintain viable populations in small areas"* (Noss & Cooperrider, 1994:140). The literature on the Rule Two debate is considered larger than any other topic in the history of applied ecology (Noss & Cooperrider, 1994:141). The debate concluded with both sides acknowledging that both "bigness" and "multiplicity" are essential criteria for establishing a reserve system (Soule & Simberloff, 1986). According to Noss and Cooperrider (1994:139), most of these rules have now been validated by experience.

Conservation biologists believe that it is not necessary to have detailed studies of every human-sensitive species before decisions are made of reserve network design (Noss & Cooperrider, 1994:141; Soule & Simberloff, 1986). Instead, they suggest there are five generalisations (From Thomas *et al*., 1990) for a reserve system design to be widely accepted among ecologists and conservation biologists (Noss & Cooperrider, 1994:141):

1. Species well distributed across their native range are less susceptible to extinction than species confined to a small portions of their range.
2. Large blocks of habitat containing large populations of a target species are superior to small blocks of habitat containing small populations.
3. Blocks of habitat close together are better than blocks far apart.
4. Habitat in contiguous blocks is better than fragmented habitat.
5. Interconnected blocks of habitat are better than isolated blocks, and dispersing individuals travel more easily through habitat resembling that preferred by the species in question.

A sixth is added for species particularly sensitive to human activities and therefore in greater need of protection:

6. Blocks of habitat that are roadless or otherwise inaccessible to humans are better than roaded and accessible blocks.

These guidelines are very similar to those proposed by Diamond 15 years earlier and therefore have proven to be robust and the “best-supported generalisations” offered by conservation biology (Wilcove & Murphy, 1991).

By 1986 it was widely accepted that most parks and nature reserves were too small to protect the biodiversity they contained (Schonewald-Cox & Bayless, 1986). According to Soulé and Terborgh (1999:11) there is no current scientific formula for determining minimum viable areas for the preservation of vegetation or habitat types, except by reference to the needs of particular species. However, a recent field study (Radford, Bennett, & MacRaild, 2004) in Australian rural landscapes has suggested a 10% vegetation cover threshold is necessary for sustaining indigenous avifauna.

While helpful, it is now recognised that the application of island biogeographic theory to terrestrial systems has its limitations. Bennett (2003:163) states that nature reserves or patches are not *"islands of natural habitat within a sea of developed land."* While the analogy from island biogeographic theory has illustrative value, its fundamental weakness is that unlike true islands surrounded by water – an environment inhospitable to terrestrial flora and fauna – reserves [and patches] are surrounded by modified and varied land uses, stocked with their own fauna and flora. Therefore, reserves are not isolated by an ecologically neutral matrix; they are subject to a host of pressures from their surrounding environments of animals, plants, wind and water that do not stop at the reserve boundary. Reserve management, however, often does stop at the boundary, with reserve managers having little or no authority to influence adjacent land use and practice. Therefore reserve managers have little capacity to counteract ecological processes outside reserves that adversely effect ecosystems within reserves (Bennett, 2003:162-163). These are points we shall return to later in the literature review.

C. CORRIDORS

Ecological connectivity is a fundamental concept in landscape ecology (Forman & Godron, 1986). Wilcox and Murphy (1985) considered *"habitat fragmentation is the most serious threat to biological diversity and is the primary cause of the present extinction crisis."* Advocates for corridors consider the best argument for corridors is that habitats of natural landscape were originally interconnected (Noss, 1987:162; Soule & Terborgh, 1999). Harris, an influential early forest ecologist, was also one who accepted corridors as a legitimate principle and tool in the conservation of biodiversity (L. Harris & Scheck, 1991).

Early interest in habitat corridors centred on potential to facilitate movement of game animals in human-altered landscapes (Noss, 2006a), and then theoretically as avenues for colonization of habitat patches (MacArthur & Wilson, 1963, 1967). Interest exploded following application of island biogeographic theory to the design of nature reserves on the 1970s (e.g. Diamond, 1975; D.S. Simberloff & Abele, 1976; Wilson & Willis, 1975) and was followed by consideration of corridors as fundamental structural elements of landscapes (Forman & Godron, 1986).

However, this history and the effectiveness of ecological corridors and connectivity issues have been the subject of another prolonged and vigorous debate. Famously, Simberloff & Cox

(1987) and Simberloff, Farr, *et al.* (1992) challenged what they considered popular and uncritical support for movement corridors on several bases:

- 'Paucity' of critical data supporting claims for their effectiveness. Widespread application followed Wilson and Willis'(1975) original proposal for corridors based on MacArthur and Wilson's (1963; 1967) equilibrium theory of island biogeography. Their approach was reprinted in the World Conservation Strategy (IUCN, 1980), and with this level of 'endorsement', it was then accepted and taken up by the UNEP and WWF, despite a *"dearth of evidence"* (D.S. Simberloff *et al.*, 1992:494) about the universal usefulness of corridors. Hobbs and Hopkins (1991) described the support for the effectiveness of corridors as, *"now almost an article of faith"*.
- Uncertainty over the optimal width of corridors.
- Failure to consider the risks and potential disadvantages of corridors that includes:
    - promoting a loss of gene pool;
    - facilitating the spread of catastrophes such as fire, disease and introduced species (though they concede that predators reach patches regardless of corridors);
    - increasing edge effects through the expansion of elongated habitat forms;
    - acting as species sinks, especially where corridor quality is low; and
    - increasing the exposure of target species to humans and domestic animals. (D.S. Simberloff *et al.*, 1992)
- Questionable effective use of limited conservation dollars: Opponents considered insufficient analysis had been undertaken to facilitate comparisons with other strategic conservation options. (D.S. Simberloff *et al.*, 1992).
- Doubtful universal applicability of corridors (D.S. Simberloff *et al.*, 1992)

Answering these criticisms, advocates for corridors claimed that there was no time to test the efficacy of corridors, that *"corridors can't hurt, even if the possible biological costs could be discounted"* and that, *"all corridors should be preserved now, because there is insufficient time to find out all their usefulness"* (D. A. Saunders & Hobbs, 1991). Others contended that in the face of uncertainty it was prudent to maintain or restore "natural" kinds of corridors (D.S. Simberloff *et al.*, 1992:494)

> *"…much of the current literature concerning corridors fails to consider potential disadvantages and often assumes potential benefits without the support of sufficient biological data, or even explicit recognition that such data are needed. Costs seem often to have been ignored."* (D.S. Simberloff & Cox, 1987:69)

Noss (1987) conceded some validity to the criticisms about a lack of evidence, agreeing that corridors cannot be applied universally. However, he re-affirmed the value of corridors:

> *"Any reasonable conservation strategy must address the overwhelming problem of habitat fragmentation... Many of the potential disadvantages of corridors could be avoided or mitigated by enlarging corridor width or by applying ecologically sound zoning regulations. Corridors are not the solution to all our conservation problems, nor should they be used as a justification for small reserves. But corridors can be a cost-effective complement to the strategy of large and multiple reserves in real-life landscapes."* (Noss, 1987)

Noss envisioned corridors as only one conservation tool, a complementary (albeit critical) component of an integrated landscape conservation strategy. He cited support for corridors from many conservation biologists, and that if habitat fragmentation is the major cause of species decline, then *"conservation strategies might be evaluated on the basis of how well they counter the effect of fragmentation in the real landscape"*. He proposed two ways to counter fragmentation - to increase effective habitat area and to increase connectivity. Each of these needs to be evaluated in the context of an integrated landscape conservation strategy.

In a later response to ongoing criticism of Simberloff and others, Beier and Noss (1998) maintained their defence of corridors after a decade of debate and uncertainty. While agreeing with critics that many studies they reviewed were inconclusive or flawed, they believe other, well-designed, studies suggested that corridors are a valuable conservation tool. They argued against the need for replication or controls to test the validity of experiments on corridors. Instead, advocating that the observation of before and after results (corridors created or destroyed) on real landscapes demonstrated corridor worth more convincingly than controlled experiments. Beier and Noss (1998:1249) could not find evidence of negative impacts of corridors. They also concluded that the number and rigour of studies on corridor issues was increasing and that the weight of evidence clearly supported the use of corridors. They maintained that,

> *"conservation biologists generally agree that landscape connectivity enhances population viability for many species and that, until recently, most species lived in well-connected landscapes"*. (Beier & Noss, 1998:1242)

This is a view shared and supported by Soulé and Terborgh (1999). Writing much later on corridors, Crook and Sanjayan (2006a:12) suggest that the precautionary principle would argue that it was wiser to prevent harm to biodiversity than to seek to repair it. Beier and Noss (*ibid*) conceded that corridors should be considered alongside the costs and benefits of alternatives, but reject the criticism that corridors are expensive because expense is not uniquely relevant to corridors, which can be far cheaper than alternatives.

In a follow-up article, Noss & Beier (2000) believe there is greater consensus among conservation biologists on corridors than the debate indicates, and challenge conservation biologists to give more recognition to this than academic dispute over what they consider minor disagreement. The conclusion from their own review of evidence is that well-designed studies support the utility of movement corridors as a conservation tool and that,

> *"…in the absence of complete information, it is safe to assume that a connected landscape is preferable to a fragmented landscape"* (p.1250)

Dobson *et.al.,*(1999: 155) note that not every species or ecological process requires corridors or physical connectivity. So, while acknowledging the popularity of corridors, Dobson *et.al.* (1999:153-155) also recognise that corridors are not always the best solution and require the consideration of several factors:

- Trade-offs - the cost of corridors versus enlarging existing habitat
- Maintenance of connectivity - fences, vulnerability to human activity etc
- Edge habitat - vulnerable to deleterious effect
- Political costs - requires land-use patterns to be altered, thus forces people using land (whether public or private) to give it up or change their behaviour (which can also occur over enlarging fragments)
- Global climate change may render corridors ineffective. But still support for positive impact if corridors are wide enough (Also Hobbs & Hopkins, 1991)
- Infectious disease & pest species – corridors may facilitate their spread. Movement of normal infectious disease, however, may be advantageous.

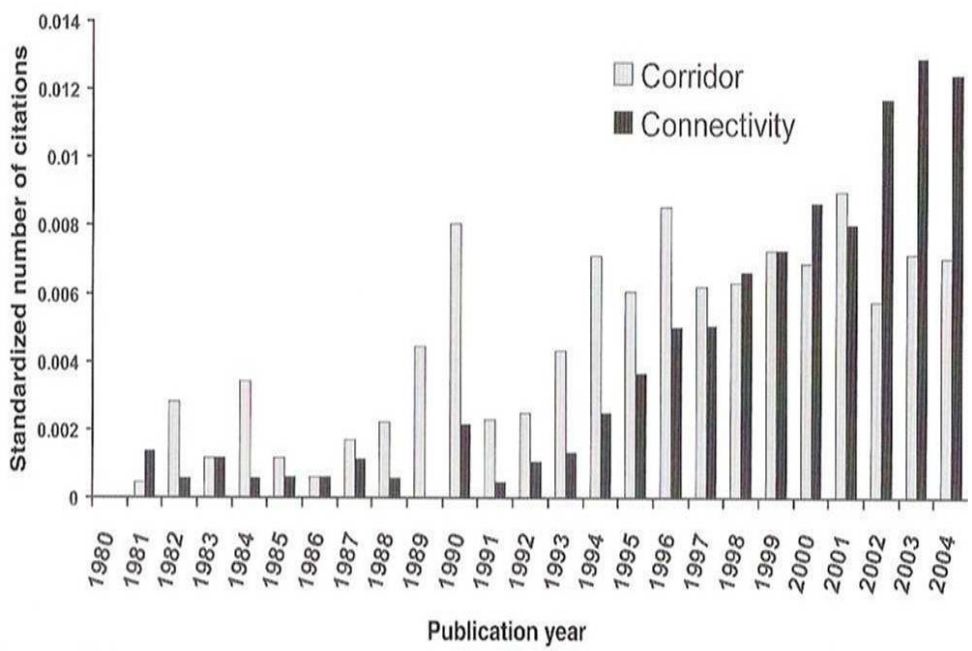
Other options suggested by Dobson *et al.* (1999:152) include artificial translocation, other forms of landscape management (e.g. managing matrix so animals can easily pass through), and stepping stone patches. But they reinforce the idea that the strongest argument in favour of connectivity is the simplest - most species evolved in a heterogeneous, extensively-connected landscape (Dobson *et al.*, 1999:158-159).

Significantly, the proceedings of an international workshop held earlier in Western Australia in 1989 on '*The Role of Corridors'* (D. A. Saunders & Hobbs, 1991) and attended by numbers of the world's leading biologists and ecologist concluded that while there were some uncertainties in the effectiveness of corridors in all situations, that overall they are a significant and beneficial conservation tool. More recently, Soulé & Terborgh (1999) reinforced the "scientific basis" for corridors and their part in effective national and cross-national ecological networks.

D. CONNECTIVITY – MOVING FORWARD

Connectivity has now been established as an important consideration in reserve design and broader landscape management, and that corridors are often the best (but not the only) way to achieve connectivity. Much of the interest now is on the issue of how to design corridors (or alternately, a suitable landscape matrix) for particular species or sets of species in particular cases (Noss, 2006b:4). A literature review by Crooks and Sanjayan (2006a) of twenty three major conservation journals between 1980 and 2004 showed a marked shift from a focus on corridors to that of connectivity. The results are shown in **Figure C4**.

Figure C4. **Increasing Focus on Connectivity**. A graph showing scientific papers published each year from 1980 to 2004 in 23 major landscape ecology, conservation biology, and ecology journals with the terms "connectivity" or "corridor(s)" in their titles or keywords. (Source: Crooks & Sanjayan, 2006a:6)



Research specifically on connectivity is a relatively recent trend, one that reflects heightened concern over the impacts of accelerated habitat fragmentation (Crooks & Sanjayan, 2006a:7). This trend also parallels the corridor controversy. Studies on connectivity have rapidly increased and now outnumber corridor studies two to one. Haddad and Tewksbury (2006) suggest connectivity studies are still in their infancy. However, corridors have tended to be a primary (albeit controversial) conservation tool for promoting connectivity (Crooks & Sanjayan, 2006a:5).

A crucial point is that the concept of connectivity is entirely dependent on the scale, species or process in question (Crooks & Sanjayan, 2006b:5). One of the most frequently used definitions of connectivity has been supplied by Taylor *et al* (1993:571): *"The degree to which the landscape impedes or facilitates movement among resource patches."*

Connectivity is essentially the opposite of fragmentation. Instead of continuing to break the ecological landscape into pieces, the goal is the preservation of existing connections and the restoration of severed connections. (Noss & Cooperrider, 1994:151)). Functional connectivity is essential rather than simple physical connectivity. Therefore, connectivity is not just corridors. Connectivity is affected more by the suitability of the overall landscape matrix than by the presence or absence of discrete corridors (Noss & Cooperrider, 1994:151). The work of Forman (Forman, 1991, 1997; Forman & Godron, 1986) and, more recently, Radford *et al.* (2004) have reinforced this principle.

The acceptance and importance of corridors as a conservation tool is underscored by the recent number of books or major reports that focus on or include significant content on connectivity and corridors (e.g., Catchpole, 2006; Hellmund & Smith, 2006; Hilty, Lidicker Jr., & Merenlender, 2006; Lindenmayer, Crane, & Michael, 2005; Piper, Wilson, Weston, Thompson, & Glasson, 2006; G. Saunders & Parfitt, 2005). The emerging emphasis on functional connectivity is comprehensively highlighted by Crooks and Sanjayan (2006a) who describe habitat destruction and fragmentation as the primary proximal threats to biodiversity. However, it is fragmentation that not only reduces the total amount of habitat, but simultaneously isolates remaining habitat, prevents movement and ecological processes in previously connected landscapes. They state that without natural levels of connectivity native biodiversity is endangered (Crooks & Sanjayan, 2006b:9), but also caution that:

> *"Connectivity between reserves should not be considered a substitute for conservation of large core areas, connecting protected areas with linkages may be an effective way, and often last option, to increase the effective area of some reserves and the population size of threatened species."* (Crooks & Sanjayan, 2006b:9).

The approach of Forman (Pers.comm. 2006) would agree with this caution. He believes there is no point in addressing corridors unless what he calls "large green blobs" exist and their protection secured.

Table C1. Types of Connectivity Function

Linkage Function	Characteristics
Habitat	• Naturally linear habitat • Important to protect, even if they have limited value as movement corridors • Have other ecological values (rich soils, high biological productivity, microclimates, abundant insect and plant food, while vegetation and substrates act as nests • Wide protected linkages act as extensions of core reserves
Home range movement	• Function most associated with corridors (Soule & Gilpin, 1991) • A core reserve may not include a daily or single annual home range of a larger species. • Maintaining safe movement opportunities is a matter of protecting species from human interference and road mortality. Every species faces mortality risks when moving about its home range on a daily or seasonal basis. • Minimising mortality sources – human activity, internal corridor fragmentation, predation – should be a major concern in corridor design for target species (Noss, 1987; D.S. Simberloff & Cox, 1987; Soule, 1991; Soule & Gilpin, 1991)
Dispersal	• Dispersal can potentially counteract the isolating effects of habitat fragmentation, but only if sufficient dispersal habitat remains. • For a regional metapopulation of a species to persist, enough individuals must move between patches to balance extirpation from local patches (den Boer, 1981). Preserving natural linkages between populations may increase the chance of metapopulation persistence. • Dispersal is more likely to be successful when habitat linkage is similar to the habitat in which a species lives (Weins, 1989). • Linkages that support resident populations may be more likely to function as long-distance dispersal conduits for those species. This increases the chance of genes flowing in both directions. • Stepping stone habitats – none separated by impenetrable barriers or distances greater than those commonly traversed – can also be acceptable as effective corridors. • Long-distance dispersal corridor design must consider the entire life history needs of species (Beier & Loe, 1992; Noss & Cooperrider, 1994:155). Considered prudent to maintain or establish wide habitat corridors whenever linking areas farther apart than normal juvenile dispersal distances, based on the observation that ranges are commonly rectangular or elliptical (Noss & Cooperrider, 1994:155).
Long-distance range shifts	• Provide for long-distance migration of species in response to climate change. • Models of global warming predict relatively rapid shifts in habitat conditions in most regions over the next half century (Flannery, 2005). • A 3°C rise in average global temperature will result in a 250km lateral and 500m altitudinal shift in environmental ranges (Noss & Cooperrider, 1994:156). • Many species will not be able to migrate fast enough, even along ideal corridors. Species with limited and discontinuous distributions or poor dispersal capacities are at high risk of extinction • The best way to assist adaptive migration in response to climate change is to maintain intact environmental gradients (Noss & Cooperrider, 1994:156).

Convinced of the critical nature of connectivity in sustainable biodiversity conservation and the key role corridors can play, Merriam & Saunders (1993) produced a set of guidelines for developing corridors in fragmented landscapes. Successfully applied in the context of the western wheatbelt of Western Australia, these guidelines are still pertinent and useful, particularly for developed agrarian landscapes.

Ecological linkages in real landscapes provide several functions and may influence many species. Four broad functions of corridors are listed and characterised in **Table C1**. On the significance of corridors in facilitating adaptation and migration in response to climate change, Hobbs and Hopkins (1991) expressed a high degree of uncertainty associated with predicted biotic response to rapid climate change. The effectiveness of corridors will be dependent on their characteristics. They consider corridors may facilitate movement of more mobile biota, including weedy plants, but do little for species with poor dispersal and establishment capabilities. They suggest a web of corridors will facilitate migration in any direction. If this is not possible, then should establish corridors along major bioclimatic gradients. They recommend the aim should be to include corridors in a wider strategy for providing a safety net for the biota in the face of potentially rapid climatic change (Hobbs & Hopkins, 1991).

E. ECOLINKAGES

Crooks and Sanjayan (2006a:14-15) observe that internationally the focus has moved away from debate about the need for connectivity and is now directed towards putting theory into practice and actually implementing plans for securing connectivity. They note that the biggest question today is not so much why, but how to achieve connectivity? For what target species or ecological process and at what scale?

Crooks and Sanjayan (2006a:12) reinforce Bennett's (2003:7) observation that a focus on 'corridors' is too narrow and that linear continuous corridors are only one method that facilitates connectivity. The literature now recognises several different ecological linkages or ecolinks. **Table C2** summarises eight common types of linkages.

Table C2. Common Types of Ecological Linkage

Linkage Type	Characteristics & Value
CONTINUOUS	
Landscape linkages	• Large scale, major habitat links at the landscape or regional scale • Substantial areas of habitat measured across in kilometres and connecting distance measured in kilometres to tens of kilometres or more • Can include major river systems • Their connectivity function and significance in ecological processes are often not recognised
Riparian corridors	• Form a hierarchy of natural linear habitat through landscapes • Supports a zone of vegetation that is usually structurally and floristically distinct from adjacent habitats with which it intergrades • Well-known rich habitat for fauna • Can have critical role and major effect on regional biodiversity • Often persist as remnant linear habitat in heavily disturbed environments • Act as buffer for aquatic systems and mediates exchange of nutrients and water between the two systems • Provide regulation of water quality and quantity and temperature • Stabilize stream banks and beds
Hedgerows & fencerows	• Diverse group of linear vegetated habitat in rural environments • Great variation in origin, floral composition and structure • Usually form rectilinear networks of habitat • Frequently provide links between remaining natural and semi-natural habitats • Closely associated with agricultural land and composition and structure strongly influenced by past and present land use and management • Presence, dimensions and composition affected change in response to prevailing land use and management • Hedgerows are linear strips of shrubs, small trees and some times large trees and provide property boundaries and stock barriers • Shelterbelts, windbreaks and plantations are linear strips of indigenous or exotic vegetation or trees planted by humans • Seldom support sustainable populations of threatened species without forming networks together with remnant natural habitats • Significant role in sustaining broad range of species and enhancing biodiversity in rural environments • Hedgerow decline has significant negative impacts on biodiversity
Roadside Corridors	• Transport corridors occupy significant and strategic areas of land • One of the largest and most extensive functioning systems of linear habitat on Earth • Have a significant negative ecological effect, (barrier, mortality source, disturbance) but their structural connectivity can also be strategically advantageous as roadside habitat • The wider and more suitable roadside verge the more habitat and more value in conservation role
Forest linkages	• Retention of unlogged areas of forests as wildlife corridors and habitat strips • Fundamental differences between linkages in managed forest and habitat linkages retained within agricultural landscapes – greater emphasis as retained habitat than as movement pathways, but still do not contain identical species to undisturbed forest • Often retained areas coincide with riparian buffer strips that may include links between adjacent catchments • Wider strips are more likely to retain and avifauna of forest-dependent species • Connectivity for wildlife in production forest can also be achieved by managing the entire forest mosaic (e.g. Spotted Owl on NW USA)

Table C2. Common Types of Ecological Linkages (Cont'd)

Linkage Type	Characteristics & value
DISCONTINUOUS	
Stepping stone patches	• Patches or remnants are now appreciated as a significant factor in achieving functional connectivity of ecological landscapes for many species • Enable short moves through disturbed environments where connectivity is achieved by a series of short 'hops' from stepping stone to stepping stone along the length of a linkage • Suits relatively mobile species and those tolerant of modified landscapes but unable to live in them movement • They may be natural stepping stones (e.g., a chain of wetlands and small remnants) or human such as plantation, artificial ponds or urban parks across towns and cities
Migratory stopovers	• Critical locations on migratory routes facilitating movement of individuals between breeding areas and wintering areas • These distinct areas are inextricably linked, but the affect of landscape structure on migratory movement and 'migratory connectivity' is poorly understood
Habitat mosaics	• A network is an interconnected system of corridors while a mosaic describes the pattern of patches, corridors and matrix that form a landscape in its entirety. Species movement is not dependent on an arrangements of strips or patches of favoured habitat, but on the use of the whole mosaic • Parts of the mosaic will be suitable for a particular species to live in, other parts may be unsuitable to live in but do not inhibit movements, while some parts may be relatively inhospitable • Patterns within landscapes that are composed of smaller elements, such as individual forest stands, shrubland patches, highways, farms, or towns. Historically, due to the short time scale of human observation, mosaic landscapes were perceived to be static. This focus centered around the idea that the status of a particular population, community, or ecosystem could be understood by studying a particular patch within a mosaic. However, this perception ignored the conditions that interact with and connect patches

(**Sources**: Bennett, 2003; Forman, 1995; Forman & Baudry, 1984; Forman et al., 2003:97-122; L. D. Harris, 1984; Manning, Fischer, & Lindenmayer, 2006; Radford et al., 2004)

A significant implication of this list of types of ecolinkages is that each or all of these can be used as practical tools to maintain or reconnect fragmented landscapes. None of the types are mutually exclusive of the others as they generally occupy different parts of the landscape (i.e. open landscape, stream/river/lake bank, farmland, roadside, production forest) and together form a suite of options to accomplish effective landscape reconnection.

Forman (Pers.comm. 2006), referring to *Land Mosaics* (Forman, 1995), prefers clusters of stepping stone patches as a better strategy than rows of patches. He believes this provides 'alternative routes' for wildlife, such as birds, if there is a threat in one patch and provides more stability in climate change than a row or narrow corridor strip. In his experience, Forman believes it is also easier to protect stepping stone patches than a corridor, because their effectiveness is less dependent on total land- owner compliance.

Manning *et.al.*(2006), have done work on the importance of scattered and isolated tree remnants that strongly suggests they not only can have an important habitat function but also an ecological connectivity function as stepping stone habitat in otherwise highly modified landscapes. They also suggest that there may be more ecological benefits from the protection and enhancement of such remnant trees as restoration centres than the addition of habitat to existing larger reserve areas. This work has significance in those landscapes where all that is often left are remnant trees, and reinforces their potential as both centres for and parts of a larger-scale regional conservation strategy in highly modified landscapes

Ecological linkages have a wide range of functions particularly in developed landscapes. They may constitute a substantial amount of the remaining habitat available for wildlife, support resident individuals or populations of animals, and play a key role in maintaining the diversity of wildlife and continuity of ecological processes in heavily modified environments (Bennett, 2003:122). The early work of others such as Lamont and Blythe (1995) demonstrates that roadside corridors have long been considered an important conservation tool. While Naiman *et.al*, (1993) supported the importance of riparian corridor in advancing regional biodiversity as well as the more traditional water and land management benefits. Linehan *et.al*. (1995) showed that urban greenways that provide for a range of uses including biodiversity conservation, were recognised as a socially acceptable basis for open space planning in built or proposed urban areas. Arendt (2004) strongly promotes the need in forward urban planning to pre-identify potential open space that could contribute to a community-wide conservation network.

F. ECOLINKAGES, ECOSYSTEM SERVICES AND PUBLIC POLICY

Ecolinkages provide a multiplicity of ecosystem services. From a conservation perspective, most interest in ecological corridors or linkages has been in their role as pathways for the movement of flora and fauna through hostile environments. Little consideration has been given to their wider ecological role in the landscape and their broader benefits to society (Bennett, 2003:97). Forman (1991), reviewing landscape corridors and their implication for public policy, identified over two dozen benefits to 'societal issues' from a network system of natural-vegetation corridors. **Table C3** reproduces Forman's list of several categories of public policy significantly influenced by landscape corridors and associated issues.

The significance of this list of potential ecosystem services is that it draws the importance of ecolinkages beyond simply their intrinsic value and promotes their protection or development as having direct social, physical and economic benefit to human interests.

Table C3. Six Areas of Public Policy Significantly Influenced by Natural Corridors

Public Policy Area	Issue
1. Biodiversity Management	• Habitat for plant and animal populations • Refuge for populations in harsh environments • Conservation of rare species • Movement for wide-ranging species • Dispersal between isolated populations • Maintenance of ecological processes
2. Water resources	• Surface drainage patterns • Ground water recharge • Flood mitigation and control • Sedimentation and holding capacity of dams and reservoirs • Water quality and temperature • Nutrient levels and eutrophication
3. Agriculture and timber production	• Soil erosion by wind and water • Windbreaks for crops, pasture and livestock • Ground water levels and condition • Timber production • Firewood • Fruits, berries and other natural produce
4. Recreation	• Wildlife observation • Hunting and fishing • Tramping, camping and recreational use • Landscape aesthetics
5. Community and cultural cohesion	• Cultural identity of rural or suburban landscapes • Links with historical land use • Property boundaries • Privacy
6. Climate change	• Pathway for redistribution of populations • Habitat for species with limited dispersal ability

(**Source**: Forman, 1991:81)

Forman (1991:81) also recommends three broad strategic advantages of a landscape corridor/patch network:

- they give integrity to existing random patchwork of ecosystems and land uses in the landscape;
- they give integrity to the often random patchwork of laws, regulations, practices, agencies and jurisdictions affecting; land;
- they provide a clear objective that landowners, decision-makers and diverse scholars can readily understand and communicate.

This significance of ecolinkages also commends them as legitimate and important practical tools for implementing aspects of the public policy areas identified in **Table D3**. Recognising the environmental services of ecolinkages also provides an important additional opportunity to recruit support, participation and funding for ecolinks projects. This list of ecolinks environmental services can also be applied to entire landscape ecological restoration programme involving the maintenance or development of networks of corridors, buffers and patches.

G. ECOLINK MANAGEMENT

The management of corridors to maintain and optimise their contribution as habitat and movement links has also come under the spotlight. Loney and Hobbs (1991:299) categorise corridors as natural (e.g. riparian), remnant (i.e. left after landscape fragmentation) or cultural (i.e. artificially constructed, e.g. hedgerows). Each category of corridor requires different management depending on their mode of origin and function, and highlight a lack of guidelines on management to secure or improve ecological function. Historically, management has been predominantly concerned with either habitat, shelter or aesthetic value – not faunal movement.

Management difficulties arise because of the linear nature of corridors, and the presence of edges and disturbance both inside and outside of corridors. Many corridors (e.g. road verges) do not have nature conservation as their primary role, and this leads to conflicts of interests. Loney and Hobbs (1991: 299) recommend an integrated management strategy for corridors, whose requirements are modified by the width of each corridor, and they provide clear management priorities recognising:

- the maintenance of existing corridors
- the rehabilitation of degraded corridors
- the establishment of new corridors

One of the few attempts at any kind of guidelines for corridor management, Hussey *et al.* (1989) produced a readable and succinct guideline for land managers to assist them manage "linear remnants".

H. EDGE EFFECTS

The linear shape of habitat corridors and the relatively small size of stepping stones means that the ratio of edge to area is often high in linkages compared to large core areas (Bennett, 2003:134). As a result, linkages are particularly vulnerable to what is termed the 'edge effect'.

In human-dominated landscapes, processes and impacts stemming from outside remnant habitats are likely to be as important, or more important, than processes within habitat in determining conditions in the habitat (Bennett, 2003:134). A range of biological and physical effects occur along edges that can directly or indirectly affect wildlife. **Table C4** summarises the main type of edge effects.

Bennett (2003:136)says that edge disturbance is greatest where there is a sharp contrast between two types of habitat, such as forest and farmland. Young and Mitchell (1994) showed that changes to the microclimate in forest patches adjacent to cleared farmland in New Zealand extended from 30m to more than 100m into podocarp broadleaf forest, depending on the edge aspect. Impacts are less marked at interfaces between two forest types.

Noss (1983) pointed out that weedy and edge-adapted species were favoured by fragmentation, and sensitive native species declined, and that therefore, the net effect of fragmented landscapes on regional biodiversity was negative. Narrow habitat corridors within rural environments, such as riparian strips, shelterbelts and roadside verge, may effectively be entirely edge habitat (Bennett, 2003:137). To minimise edge effects in any situations Bennett (*ibid*) recommends active management.

Table C4. **Five Main Types of Edge Effect.**

Type	Comment
Microclimates	Involve the effect of solar radiation, light, humidity, temperature and wind speed (Bennett, 2003:134; Forman & Godron, 1986; Lindenmayer et al., 2005:114). Consequently, newly created edges following exposure from clearing is likely to cause changes
Plant community composition and structure	Edge plant communties are characteristically different from the interior (Bennett, 2003:135). This arises from plant species responses to altered micro-climate conditions, and from invasion by plant species from adjacent habitat that also tend to displace native plants (Lindenmayer et al., 2005:114)
Altered fauna habitat	Changes in plant communities means altered fauna habitat (Bennett, 2003:135). This may benefit some species and be disadvantageous to others
Thriving edge specialists	Species that are edge specialists or are typical of disturbed lands can invade and become predators, competitors or parasites of 'interior' species (Bennett, 2003:135-136)
Adjacent land use impacts	Edge habitat is prone to disturbance processes from activities in adjacent land (Bennett, 2003:136). This may include drift from fertiliser and other farm chemicals, impacts of stock grazing, fires, placement of access tracks and control burns along edges, and recreational disturbance and littering

Related to edge effect, the width of linkages is particularly important for how well linkages actually function (Bennett, 2003:137-140). Maximising width is one of the most effective options to increase the effectiveness of linkages for biodiversity conservation (Bennett, 2003:137). Harris and Scheck (1991) have proposed a 'rule of thumb' guide for the width of corridors relating to their function and time scale over which they need to operate:

> *"for the movement of individual animals where much is known of their behaviour and the corridor is intended to function over weeks or months, the appropriate width can be measured in metres;*
>
> *For the movement of a species, when much is known of its biology and when the corridor is expected to function over years, the width should be measured in 100s of metres;*
>
> *When the movement of entire assemblages is considered and/or when little is known of the biology of the species concerned, and/or the corridor is intended to function over decades, the appropriate width must be measured in kilometres."*

In light of this, Bennett (2003:140) cautions that determining a suitable width for corridors may seem imprecise, particularly where there is a lack of knowledge on flora and fauna, and there are competing demands for land use. In such circumstances, he suggests those planning linkages should:

- clearly identify the purpose of the link;
- use all available data about the fauna;
- apply the principles 'the wider the better' and 'as wide as possible';
- keep in mind that most existing and planned linkages are likely to be much less (rather than more) than the optimum width for long-term ecological function.

I. REPRESENTATION

Representation is one of the oldest and most comprehensive goals in conservation criteria (Noss & Cooperrider, 1994:104,105). Representation is based on the idea that *"a prerequisite for preserving maximum biological diversity in a given biological domain is to identify a reserve network which includes every possible species."* (Margules, Nicholls, & Pressey, 1988). Representation differs from 'representativeness' which seeks to protect archetypal communities and once represented as an example is then considered protected. In contrast, representation captures the full spectrum of biological and environmental variations with the understanding that this variation is dynamic and not easily classified (Noss & Cooperrider, 1994:105). Because biodiversity occurs at many levels, biodiversity conservation should seek to represent all species, ecosystems and landscapes. In practice, vegetation usually provides a good short-term surrogate or "coarse filter" for biodiversity (Noss & Cooperrider, 1994:106). The practical advantages of a coarse filter include efficiency and cost effectiveness (it is easier to deal with even hundreds of ecosystem types than thousands of species) and the assumed ability to protect species that little or nothing is known about and cannot begin to inventory individually. A fine filter of rare species inventory and conservation planning is also needed as a complement, but runs the danger of getting bogged down in too much detail.

Margules *et al.* (1988) concluded that a significant amount of habitat must be protected to represent biodiversity adequately:

> *"[T]he belief that biological diversity is 'reasonably secure' … with the dedication of one or a few well chosen reserves in an ecological reserves in an ecological domain is unfounded. The reality is that a very large number of reserves seems to be necessary to secure biological diversity."*

Noss and Cooperrider (1994:109) suggest that representation is best dealt with by focussing on vegetation and habitat types, environmental gradients, hot spots of species richness, and centres of endemism.

J. LANDSCAPE MOSAICS AND CONTINUUMS

A development on the focus on remnant forest patches and corridors, Forman and Godron (1986) introduced and then Forman (1997) developed the concept of the patch-corridor-matrix model - the landscape mosaic. This model recognised that every land mosaic is composed of only three types of spatial elements: Every point is either within a patch, a corridor, or a background matrix (Forman, 1997:6), whether the land mosaic is forested, dry, cultivated or suburban. In this simple model patches, corridors and matrix are the building blocks that form a landscape matrix. This model provided a handle for study and for establishing patterns and principles for landscape design.

One of the significant contributions of this model is that it helped recognise that all land matrices are heterogeneous, whether natural or developed and that heterogeneity is a fundamental element of any 'natural' landscape.

Recent work by Manning *et al.* (2004), has challenged aspects of what they consider the anthropocentric 'classic habitat fragmentation model' that characterises landscapes as simply either fragmented or intact, rather promoting a more ecocentric 'landscape continuum model'.

The latter recognises that in nature the boundaries are less sharply defined and instead more often represent various environmental gradients and that even so-called unfragmented landscapes are not homogenous, that so-called ‘fragmented landscapes’ may in fact not be viewed that way by faunal elements, and that, therefore, issues of connectivity vary with scale and species. Facts they consider need to be recognised in the design of any ecological network at any scale. This would seem to be a view shared by Noss in his most recent work (Noss, 2006a).

The discrete elements of the mosaic model is still a useful approach for modelling landscape dynamics. However, the reality of landscape continuums should temper any restrictive interpretation of the boundaries between the various mosaic elements.

APPENDIX D – INTERNATIONAL ECOLOGICAL NETWORK PROJECTS

Ecological Network Projects

	Ecological Network	**Location**
1	Global 200 Programme	Global
2	Pan-European Ecological Network	Europe & Asia
3-9	Bonn Convention: 7 agreements	Europe & Asia
10	Western Hemisphere Shorebird Reserve Network	North & South America
11	Ecological Corridor of the Americas	North & South America
12	Mesoamerican Biological Corridor	Central America
13	East Asian-Australasian Shorebird Site Network	East Asia & Australasia
14	Natura 2000	European Union
15	European Coastal & Marine Ecological Network	Western Europe
16	Carpathian Ecoregion Initiative	Czech Republic, Hungary, Poland, Romania, Slovakia & Ukraine
17	Transnational Ecological Network	Netherlands, Germany & Denmark
18	Waltonian Ecological Network	Belgium (Waltonia)
19	Interwoven Biotope System	Germany (Rhineland-Palatinate)
20	PLANECO Project	Italy (Central Appenines)
21	Netherlands Ecological Network	Netherlands
22	Swiss National Ecological Network	Switzerland
23	Cheshire ECOnet	UK (Cheshire)
24	Forest Habitation Network	UK (Scotland)
25	Network of Ecologically Compensating Areas	Estonia
26	Hungarian National Ecological Network	Hungary
27	ECONET - Poland	Poland
28	Romanian National Network	Romania
29	Territorial System of Ecological Stability	Slovakia
30	Econetwork	Moldova
31	Heart of Russia	Russia (Central Russia)
32	Ecological Network of the Orenbourg Region	Russia (Orenbourg)
33	Volga-Ural ECONET	Russia (Volga/Ural)
34	Ukrainian National Ecological Network	Ukraine
35	Conception Coast Project	United States (California)
36	Maine Wildlands Reserve Network	United States (Vermont)
37	Naya Conservation Corridor	Colombia (Naya watershed)
38	National Reserve System Program	Australia

(**Source**: G. Bennett & Wit, 2001:19)

APPENDIX E – ENGLISH BIODIVERSITY PLANNING DOCUMENTS

Planning Policy Statements, guides, research, websites, reports and miscellaneous resources relating to Biodiversity Conservation in England.

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APPENDIX F – ENGLISH INFORMATION SOURCES

A. BIODIVERSITY RESOURCES INFORMATION SOURCES

(**Source**: ODPM *et.al*. 2006:5-17)

Name	Characteristics	Examples
Natural Areas & Joint Character Areas (JCA) (p5-6)	• Natural Areas map broad biogeographical zones to provide context for strategic understanding of environmental resources & information requirements • Profiles list key habitat and species for each area • Helps regional planning bodies gain strategic understanding of biodiversity resources within region • JCA's combine Natural Areas and abiotic character. Used by English Nature as main national framework to package advice on priorities & targets	RSS for North East (ODPM, Defra, & English Nature, 2006:5; ODPM/GONE, 2002)
Natural systems information (p7)	Information on natural systems and processes in an area can be gained from agencies producing strategies such as Catchment Flood Management Plans, River Basin Management Plans, Shoreline Management Plans, and Estuary Management Plans. The Environment Agency has key information on fluvial and coastal processes, flood risks and water quality	
Designated sites (p7-8)	Up-to-date spatial information on the location and extent of international, national and local designated sites is available on the National Geographical Information System (GIS)	MAGIC (Defra et al., 2002) Nature on the Map (English Nature, 2004) KLIS (Kent County Council, Undated)
National Biodiversity Network (NBN) (p8-9)	A single internet portal (NBN Trust, Undated), from a wide range of sources, predominantly of species records, including a set of automated site reports. Data is drawn from individual national recording schemes and societies deriving information from volunteers and amateur naturalists (ODPM et al., 2006:9)	
Climate Change (p9)	Increasing body of work on the likely impacts of climate change on biodiversity	• UKCIP (UKCIP, Undated-b) • MONARCH (UKCIP, Undated-a) • BRANCH (BRANCH, Undated)
Ancient Woodland & Veteran Trees (p9-10)	Protection of ancient woodlands are a priority habitat in the UKBAP. PPS9 requires local planning authorities to identified such woodlands that do not have statutory protection. Threat maps have been produced for unprotected woodlands	• MAGIC (Defra et al., 2002) • English Nature (English Nature, Undated-a) • Woodlands Trust (Woodland Trust, Undated) • WAPIS (English Nature, Undated-b)
Mapping Networks of natural habitats (p11-15)	PPS9 promotes the identification of areas or sites for the restoration or creation of new priority habitats. One approach to this is **Opportunity Mapping** and their use in developing policies and targets for areas and regions	• Making Space for Wildlife (RSPB, 2004) • East of England Biodiversity Map (East of England Biodiversity Forum, 2005) • Oxfordshire Wildlife & Landscape Study (OWLS) (Oxfordshire County Council, Undated) • KLIS (Kent County Council, Undated)

Continued next page…..

Name	Characteristics	Examples
Biodiversity Action Plans (BAPs) (p16-18)	**UKBAP** provides a starting point for identifying regional and local biodiversity priorities. Its website provides a convenient means of accessing information on the various regional, county, species, habitat or topic BAPs which all nest within the UKBAP, and of identifying key contacts, partners, summary data, reports and guidance. **Regional** Biodiversity Partnerships to work towards developing regional BAPs and translating the UKBAP into regionally specific information. to assist RSS priorities. **Local** partnerships and BAPs translate national and regional targets into action for counties. Action plans serve a number of important functions: • Provide baseline information on our current knowledge; • Identify current conservation issues; • Set out targets to work towards; • Co-ordinate and focus action for biodiversity; • Raise awareness amongst all sectors; • Provide a monitoring framework.	• UK Action Plan 1994 • West Midlands Regional Biodiversity Partnership – Rebuilding Regional Biodiversity Project (WMBP, 2005) • North East Biodiversity Forum – regional biodiversity targets and indicators (Street & Brodin, 2004) • Wiltshire BAP (Wiltshire County Council, 2002) • Cornwall Community Strategy (Cornwall County Council, 2003)
Local site systems (p18)	PPS9 recognises that sites of local biodiversity have a fundamental role to play in meeting overall national biodiversity targets, contributing to the quality of life and well-being of the community, and in supporting research and education	Defra has recently produced guidelines on development of Local Site systems (Defra, 2006)
Local Record Centres (LRC) (p19-20)	A generic term for a single information source, often serving a specific county or sub-region. Collate, manage, and disseminate biodiversity information. Work with local species recording schemes. May also undertake habitat mapping or act as custodian of information collected by other organisations.. Supported by funding partnerships of local authority and national agencies. The intention is to have a publicly accountable 'one-stop-shop' for comprehensive and reliable environmental information upon which to plan, inline with the key principles of PPS9. The benefits of supporting an effective LRC include: • Better access to information on species and habitat occurrence for planning authorities and other stakeholders; • Early identification and conflict resolution that avoids costly public inquiries; • Reduce processing time; • Reduce cost to developers; • Biodiversity data for Annual Monitoring Reports.	• Nottingham Ecological & Geological Data Partnership (NEGDP) • Developing A Local Record Centre (The Wildlife Trust, 1999)
Local authority ecologists (p20-21)	Use of local authority ecologists is promoted to improve capacity of planning authorities through access to in-house or shared expertise in ecology. Ensures biodiversity conservation becomes integral part of all local authority decision making. Such provision intended to help authorities fulfil objectives of PPS9 by enhancing capacity to: Facilitate integration of LBAP into planning system; • Interpret environmental information & select targets and indicators; • Specialist input to community consultation exercises; • Vet adequacy of information with planning application; • Optimize development control to avoid, mitigate or compensate; • Optimize site selection.	Association of Local Government Ecologists (ALGE) provides advice on the role and other guidance in including biodiversity in the work of local authorities (ALGE, 2001, 2005)
Community knowledge (p21-22)	PPS1 expects planning authorities to build a clear understanding of profile, interests and needs of communities, their environmental values and issues. Can provide means of engaging and bringing community 'on board'	• Dartmoor 'Nature for Real' project (Dartmoor Biodiversity Project, 2002)

B. ENGLISH 'BUILDING IN' BIODIVERSITY GUIDELINE SOURCES

1. **Checklists** (ODPM et al., 2006:46). These are a helpful means of improving the efficiency of the development control process. Local authorities publish generic advice to aid applicants understanding of the issues and type of information that might be needed to be supplied with a planning application.

2. **Building in biodiversity** (ODPM et al., 2006:55-58). PPS9 states that plan policies should promote opportunities for the incorporation of beneficial biodiversity features within the design of development (ODPM, 2005:3). This recognises that design, layout and landscaping of new developments offer significant opportunity to add or enhance biodiversity conservation. Planners can now refer to a range of design guidance on the integration of biodiversity into the design of development that includes (ODPM et al., 2006:58-59).

3. **Guides for planners.** For example, *Biodiversity by Design: A Guide for Sustainable Communities* (Town & Country Planning Association (UK), 2004).

4. **Guides for cities.** For example, the London Biodiversity Partnership through English Nature, Greater London Authority, and the London Development Agency produced a *Design for Biodiversity* brochure (London Biodiversity Partnership, 2004).

5. **Guides for the building sector.** The Construction Industry Research and Information Association (CIRIA) have developed a project around buildings for biodiversity to help deliver the technical specification and guidance necessary to install vegetation on buildings for biodiversity, sustainable urban drainage and energy efficiency benefits (CIRIA, 2006). CIRIA have also produced a *Working with Wildlife* publication made up of a mixed-media ring-bound resource package giving information and good practice guidance to help those in the construction industry (CIRIA, 2004). The Chartered Institute for Water and Environmental Management (CIWEM) has published a *Habitats Guide* that features a specific chapter on buildings (CIWEM, 2004). The Building Research Establishment Ltd (BRE) is regarded by the UK's construction and property sectors as the measure of best practice and has developed standards that have been widely adopted by the construction industry as a way of reviewing and improving the environmental performance of buildings, including site ecology (www.bre.co.uk, www.breeam.co.uk).

C. EXAMPLES OF ENGLISH WEB-BASED BIODIVERSITY DATABASES

Several web-based data bases provide excellent information for all stakeholders in biodiversity conservation as strategic overviews of biodiversity resources within areas and regions:

1. **MAGIC – www.magic.gov.uk** (Defra et al., 2002, 2006) A partnership of Government departments and agencies produced the first web-based interactive map bringing together information on key environmental schemes and designations in one place. Continually updated and improved, it makes use of standard GIS tools to allow people to view and query the available data sets and layers without the need for specialist software.

2. **Nature on the Map – www.natureonthemap.org.uk** (English Nature, 2004) English Nature's website provides detail of international, national and local sites as well as UKBAP priority habitats. It provides links to other websites with environmental data. Most site boundary data is in GIS format and is able to be downloaded by planning authorities into their own data systems (ODPM et al., 2006:8).

3. **Kent Landscape Information System (KLIS) – http://extranet7.kent.gov.uk/klis/home.htm** (Kent County Council, Undated).
   Many planning authorities download national information into their own GIS systems and add more local spatial data. KLIS provides detailed information on Kent's landscape and biodiversity. It is primarily aimed at landowners, farm advisors and those involved in land-use planning, but also provides a useful information source to the public. It contains details on countryside access, landscape character, and most significantly it introduces the concept of **'Opportunity Mapping'** by identifying opportunities for habitat creation and landscape restoration (ODPM et al., 2006:8)8 . The rules for the development of the 'Habitat Opportunity' layers set out in a separate document (Lyons, Undated), but their scientific basis are not provided.

4. **Ancient woodlands & veteran trees** – www.woodsunderthreat.info provides maps that indicate threat levels to woodlands and ancient trees. PPS9 requires local planning authorities to identify areas of ancient woodland in their areas that do not have statutory protection (ODPM et al., 2006:11). Hardcopies of ancient woodland inventories of sites

greater than 2ha thought to have been continuously wooded since 1600AD, have been digitised and are now available from the English Nature website (English Nature, Undated-a), or viewed on the MAGIC website (Defra et al., 2002) . The Woodland Trust produces a website that shows ancient woodlands that are currently under threat (Woodland Trust, Undated).

D. UK INFORMATION SOURCES FOR CLIMATE CHANGE IMPACTS

1. **UKCIP – UK Climate Impact Programme (ODPM, 2004:16; ODPM et al., 2006:9; UKCIP, Undated-b). Website:** http://www.ukcip.org.uk.

   The UKCIP helps organisations assess how they might be affected by climate change, so they can prepare for its impact. The programme works with stakeholders and co-ordinates research on how climate change will have an impact at regional and national levels. UKCIP has been the catalyst for a range of regional and sectoral studies into the impacts of climate change. UKCIP is part of a wider programme of research into climate change lead by Defra (UKCIP, Undated-b). MONARCH and BRANCH are two biodiversity and climate change projects involving UKCIP.

2. **MONARCH - Modelling Natural Resource Responses to Climate Change. (ODPM et al., 2006:9; UKCIP, Undated-a). Website: http://www.ukcip.org.uk/resources/sector/projectsdets.asp?sector=3&project_ref=8.**

   The MONARCH project, run by Oxford University's Environmental Change Institute, is modelling predicted movement of species and the future location of biodiversity in the UK. Often this will result in significantly reduced suitable climatic space for species and will require planners to consider how to accommodate these changing habitat needs (ODPM et al., 2006:9).

3. **BRANCH – Biodiversity Requires Adaptation Under a Changing Climate. (ODPM et al., 2006:9; Piper, Wilson, Weston, Thompson, & Glasson, 2006; Tricker, Undated).**
   Website: http://www.branchproject.org.

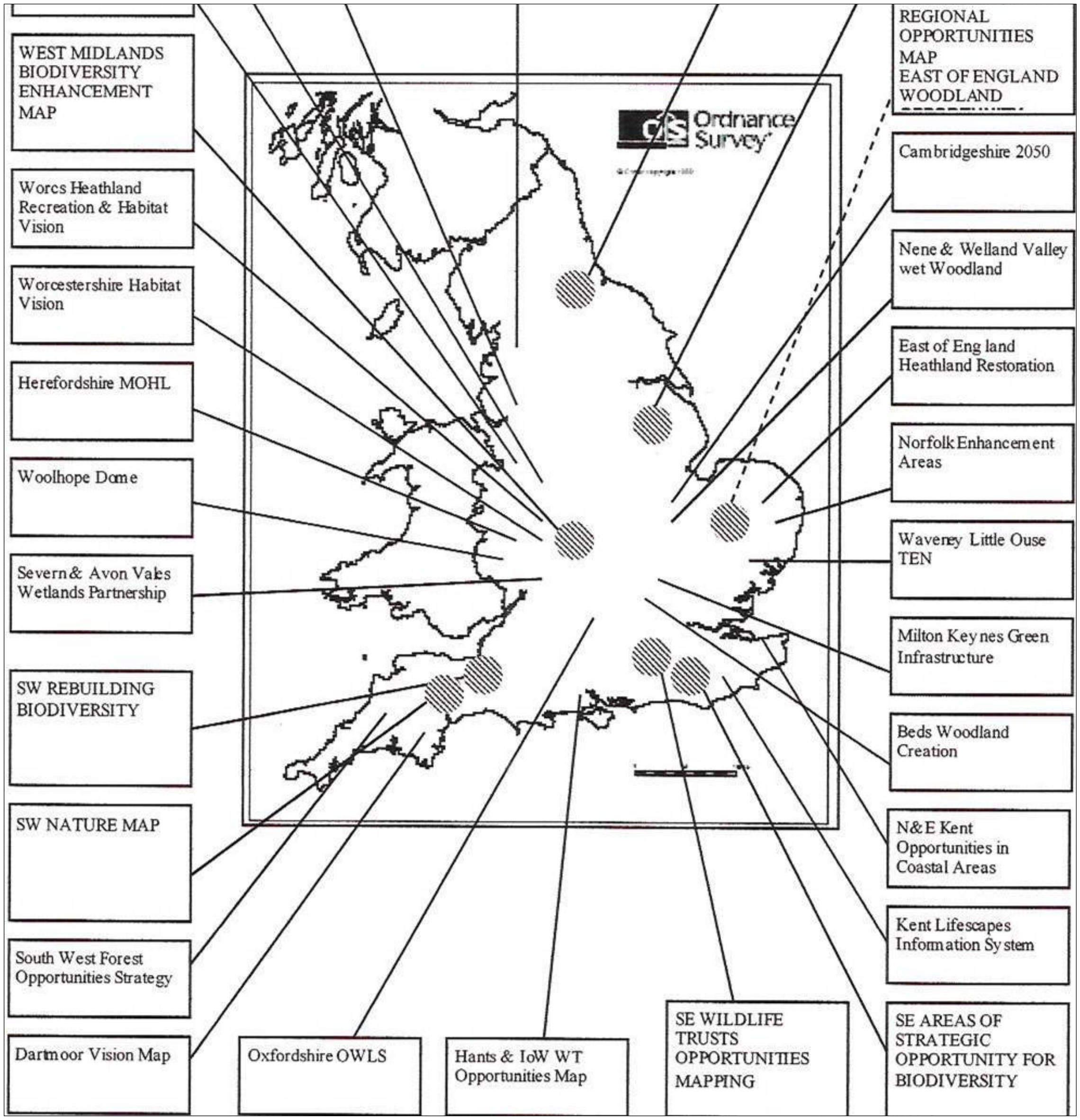
BRANCH is an interregional spatial planning project that aims to identify, develop and advocate spatial planning mechanisms to help UK wildlife, countryside and coasts to adapt to climate change. Its objective is to facilitate spatial planners, policy makers and scientists working together to:

- model how wildlife of land and coast will respond to climate change
- develop good adaptation practice and spatial planning and protected area management
- use case studies to develop planning options and tools the help wildlife adapt to climate change
- engage stakeholders, so that adaptation to climate change is integrated at all planning levels (Tricker, Undated:3).

BRANCH has developed species models on the basis of best and worst case climate change scenarios over the next 20, 50 and 80 years for England. From this developed a number of generalised possible adaptation actions:

- Reduce habitat fragmentation and increase connectivity of the landscape so that species can move in response to changing climate
- enhance population of species and maintain favourable habitat conditions for species
- encourage ‘soft engineering’ solutions to coastal and riverine flooding that incorporates dynamic, natural systems (Tricker, Undated:26).

APPENDIX G – ENGLISH OPPORTUNITY MAPPING LOCATIONS



(Source: G. Saunders & Parfitt, 2005:17)

APPENDIX H – ENGLISH OPPORTUNITY MAPPING SUPPLEMENTARY DETAIL

Planning objectives in PPS 9 on Biodiversity Protection include,

> *"to conserve, enhance and restore the diversity of England's wildlife… by sustaining and, where possible, improving the quality and extent of natural habitat."* (ODPM, 2005:2.)

The planning framework for English biodiversity conservation makes the protection, enhancement, re-creation and creation of wildlife habitat and the development of appropriate planning provisions mandatory. RSS & LDF are required to identify such opportunities and 'opportunity mapping' is the widely accepted methodology for achieving this. This section provides background and examples of opportunity mapping as defined by the English planning for biodiversity conservation.

The status, practice and approaches to opportunity mapping are set out in three key documents:

> *'Opportunity Maps' or Landscape-Scale Conservation of Biodiversity: A Good Practice Study* produced by English Nature (Saunders & Parfitt, 2005).
>
> *Planning for Biodiversity and Geological Conservation: A Guide to Good Practice* a joint production by a number of government agencies and NGOs (ODPM, Defra, & English Nature, 2006).
>
> *Planning for Biodiversity – Opportunity Mapping and Habitat Networks in Practice: A Technical Guide* from English Nature (Catchpole, 2006).

The ecological theory behind opportunity mapping comes from landscape ecology. According to Saunders and Parfitt (2005:15),

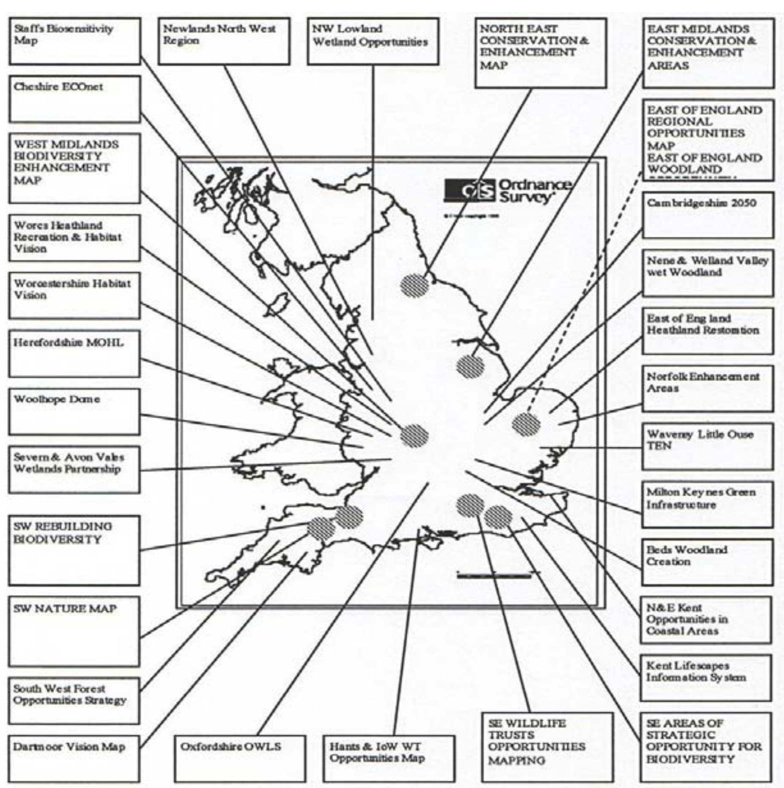
> *"…the field of landscape ecology has been developing the idea that habitat patches in a landscape do not exist in a vacuum, but are influenced by their size, their position relative to one another, and the physical structure of the landscape in between them. Bigger habitat patches, closer to one another, set in an intervening landscape which is not hostile to species movement, are likely to be more 'functional' in ecological terms.*
>
> *The message of opportunity maps is that future sustainability of habitats demands not only that existing habitat patches are protected, but that they are expanded and connected across landscapes, and that such expansion will be more feasible and appropriate in some locations than others."* (Saunders & Parfitt, 2005:15.)

This is still as novel an idea to some audiences in Britain as it seems be in New Zealand, where the more familiar traditional approach in protected areas policy has sought to protect only the best examples of different habitat (i.e. representativeness). These have often been viewed in isolation and managed to maintain their wildlife values in spite of their relatively small size and isolation. However, a landscape level approach demands a completely new perspective which views areas holistically, and recognises the effect one area of land may have on its neighbours (Saunders & Parfitt, 2005:15).

In the English situation, it is recognised that principles from landscape ecology can be used either loosely or rigidly in opportunity mapping. It may be enough to simply use the principle that the bigger and more concentrated habitat patches are in a given landscape, the better. Alternatively, theory can be applied to 'accurately' define the dimensions of ecologically functional landscapes. In practice, a full spectrum of approaches are currently being used (Saunders & Parfitt, 2005:15).

Figure J1 illustrates the widespread popularity of opportunity mapping in Britain and shows the location of known mapping initiatives within England (as at 2005).

Figure J1. Locations of Known Opportunity Mapping Initiatives in England
(Source: Saunders & Parfitt, 2005:17)



These different mapping projects express a range of approaches to opportunity mapping. The English experience has produced a ‘pool’ of approaches illustrated by **Table J1**. These approaches include highly technical approaches for ecological specialists, to the more ‘basic’ envisioning maps aimed at stimulating public understanding, support and participation. The existence of numbers of approaches represents the fact that, until 2005, there was no standards for opportunity mapping in England.

Table J1. Opportunity Map Classification and Checklist by Theme, Topic & Approach
(Source: Saunders & Parfitt, 2005:23-26)

Theme	Topic	Approach
PROCESS	**Partnership**	☐ Initiated & lead by local BAP partnership
		☐ Initiated by one or more parties, then ‘sold’ to wider partnership
		☐ One party only
	Dialogue	☐ Consultant-led exercise based on GIS data manipulation
		☐ Collective exercise within biodiversity sector
		☐ Collective exercise beyond biodiversity sector
	Scope	☐ Biodiversity agenda only
		☐ Biodiversity & landscape character
		☐ Biodiversity-led, with reference to other agendas
		☐ Equal weight for social need & environmental potential
METHODOLOGY	**Use of data**	☐ Comprehensive, verified data available & used
		☐ Comprehensive data available but not used
		☐ Data not comprehensive, map restricted
		☐ Data not comprehensive, map extrapolated
	Scientific rationale	☐ Simple sketching of areas of potential
		☐ Digitising of areas identified using simple rules
		☐ Detailed analysis of multiple data sets
		☐ Detailed ecological rationale
		☐ Detailed ecological rational plus local opinion
COMMUNICATION	**Strategic role**	☐ Assisting decision-making by others
		☐ Gaining access to the development agenda
		☐ Visualising a new targeted agenda for change
		☐ Stimulating public debate
	Portrayal	☐ Attributes for all parcels of land
		☐ Selected opportunity areas without distinction
		☐ Selected opportunity areas with attributes
		☐ Only land above a defined threshold
		☐ Definition of ecological minima
	Commentary	☐ Policy-making audience only
		☐ Planning: Land use and public audiences
		☐ General non-technical public audience
		☐ Practical land manager audience
		☐ Internal audience only
	Media	☐ Leaflet
		☐ Local paper
		☐ Website
		☐ Interactive website
		☐ Directed to policy or technical audience only
		☐ Landowners
		☐ Published technical manual

The experience of those involved in opportunity mapping initiatives to date has generally shown that opportunity maps will be most successful with the following features (Saunders & Parfitt, 2005:46):

- Clear purpose
- Established on sound partnerships moving out to wide stakeholder dialogue
- Broad consideration of heritage agendas
- Methodology that fits the purpose
- Reliable data
- Clear, well-explained map

An independent survey of these mapping initiatives recommends a number of simple good practice principles to encourage a consistent and effective approach, while acknowledging a need for flexibility (Saunders & Parfitt, 2005:46). **Table J2** summarises the good practice principles developed from a review of the various opportunity mapping initiatives.

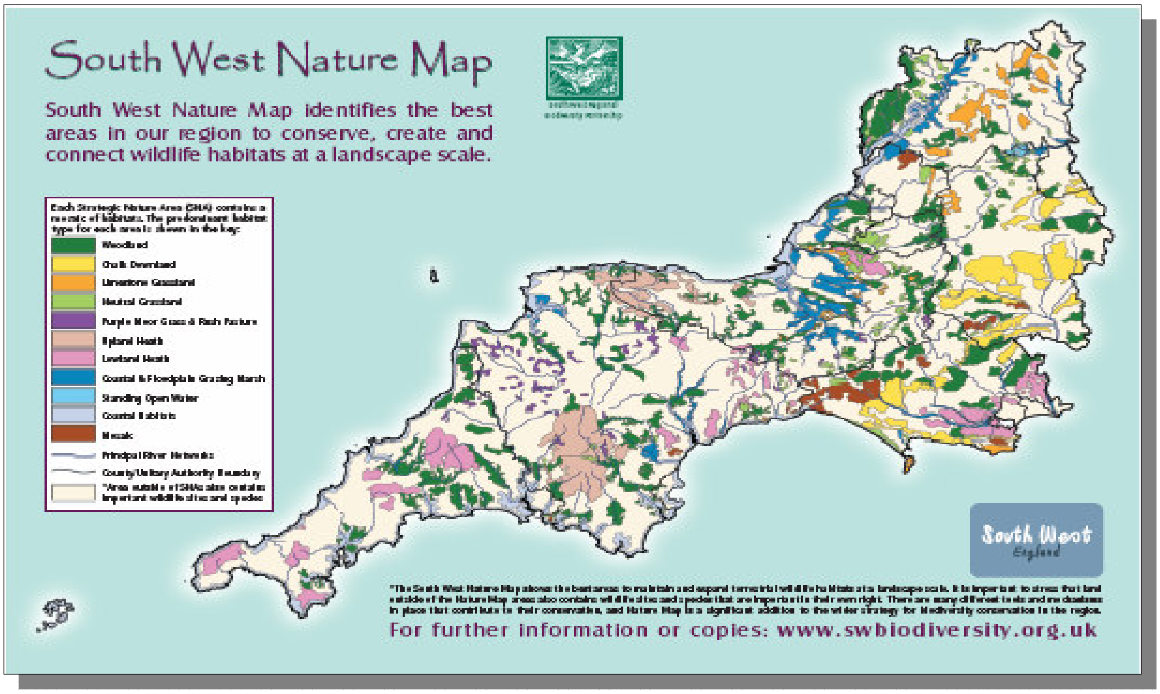
Table J2. Good Practice Principles for Opportunity Mapping
(Source: Saunders & Parfitt, 2005:8,16,22-26,46-53)

PROCESS	**Derived from other areas of policy development and applied to map-making. The process is important in order to gain widespread support and 'buy-in' to be effective.**
	• Clarity of purpose • Links from and to the relevant BAP • Based on strong partnerships from the beginning • Partnerships should be on-going to invest long-term in the development of the map and the implementation of the action it proposes • Ensure continuity across boundaries and between scales of mapping • A dialogue with local expertise to give authority to the map • Links to other sectors e.g. historic environment, landscape, resource protection, access.
METHODOLOGY	**Technical learning from mapping experience**
	• Use the best data available, but not necessarily constrained by its absence • Adopt a level of complexity or simplicity consistent with the map's purposes • Use at least a basic ecological rationale • Use a landscape framework to provide for a holistic coverage of the subject area
COMMUNICATION	**Communication of map products themselves**
	• Designed to suit its purpose • Understandable to look at • Avoid misunderstanding through careful wording accompanying the map • Communicate map to intended audience through right media

ADDITIONAL CASE STUDIES - OPPORTUNITY MAP EXAMPLES

A few additional brief case studies further illustrate the above good practice principles and different approaches to opportunity mapping.

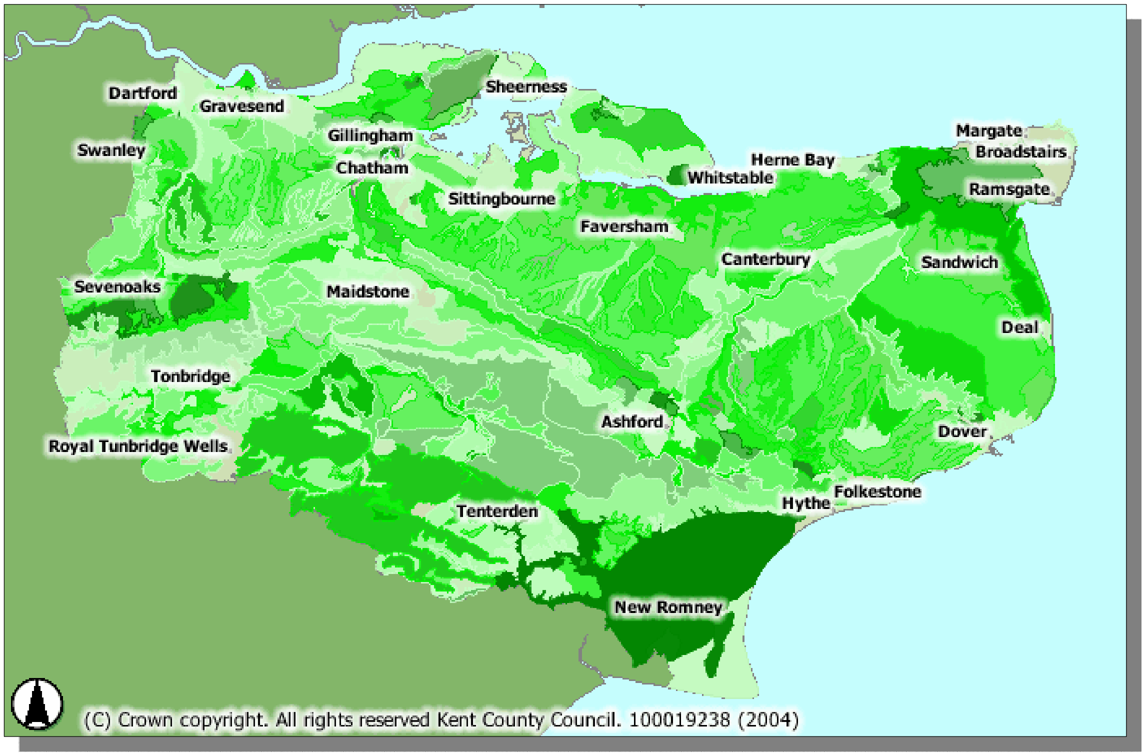
Case Study 1 – South West Nature Map (Figure J2) (Source: Saunders & Parfitt, 2005:66-67)



- A focus on large-scale projects in selected zones that can maintain, restore and re-create the region's biodiversity assets.
- Illustrates where major biodiversity asset concentrations are found and where BAP targets for maintenance, restoration and re-creation might be met
- Its purpose is to influence planning processes, particularly the RSS
- Assists development of partnership activity for biodiversity in the region
- Provides a non-technical, publicly understandable approach that "produced a disarmingly simple map appreciable by many audiences".

Case Study 2 - Kent Lifescapes Information Systems (K-LIS) (Figure J3)

(Source: Saunders & Parfitt, 2005:61-62)



- K-LIS provides web-based access to spatial information about the landscape and biodiversity of Kent, including targets for habitat restoration and creation at the local and strategic levels.
- Excellent interactive webpage maps - See www.kent.gov.uk/klis
- Web maps can be viewed down to the individual street level.
- Based on landscape ecology ecological rules
- Aimed at strategic advisors and decision-makers in local government and agencies
- This interactive map illustrates graded habitat opportunities – the darker the colour the higher the habitat opportunity.

Opportunity maps are, by definition, agenda setting (Saunders & Parfitt, 2005:55), because they "look to the future" and visualise an ambitious forward agenda for ecological renewal, while at the same time also balancing and accommodating the needs of other environmental and socio-economic development. It is suggested that the opportunity mapping process could be a natural locus around which biodiversity, landscape and other agendas could join in a spatial/landscape context (Saunders & Parfitt, 2005:56).

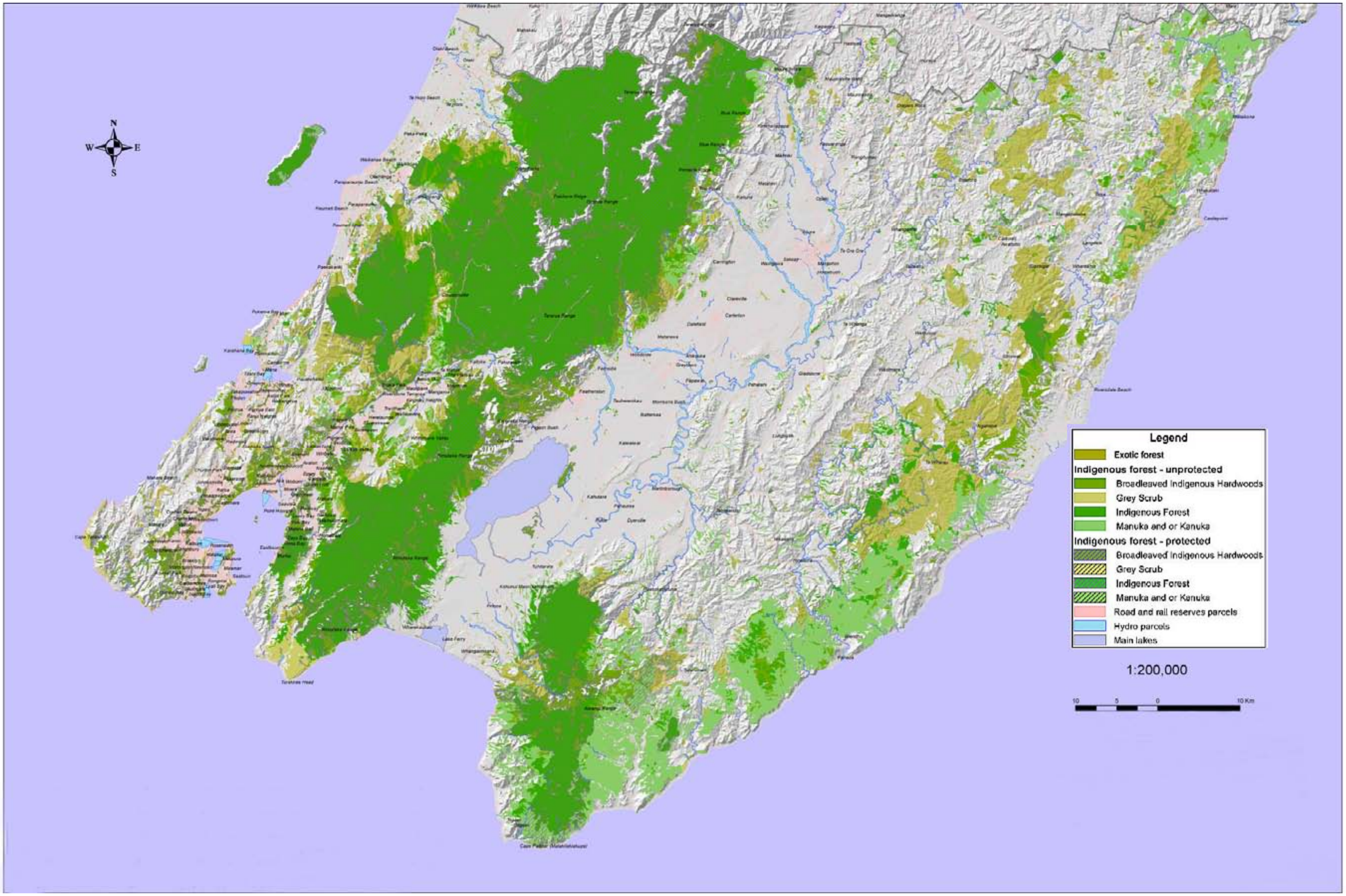
Opportunity maps provide a forum to integrate the agendas of competing interests. Britain experiences a ‘silo mentality’ between different land use and policy sectors, where economic, social and environmental agendas for land use are advanced without reference to one another. Even amongst the heritage sectors and within the biodiversity sector, different NGOs and interest groups have promoted different emphasis and priorities that send mixed messages to their target audiences. Opportunity maps have provided an opportunity to overcome some of this confusion, by offering a tool or vehicle for integrating the strategic aspirations of the conservation sector into a single spatial agenda which can be owned collectively by all parties. It is therefore suggested, therefore, that this will enable conservationists to speak with one voice, and direct their combined energy to the locations most capable of providing the greatest outcomes (Saunders & Parfitt, 2005:15). Opportunity mapping that is sustainable, requires a partnership approach with potential for this to occur not only within the biodiversity sector, but beyond to social and economic agendas (*op.cit.* p.16).

APPENDIX I – LEEP MODEL 'TEST PANEL'

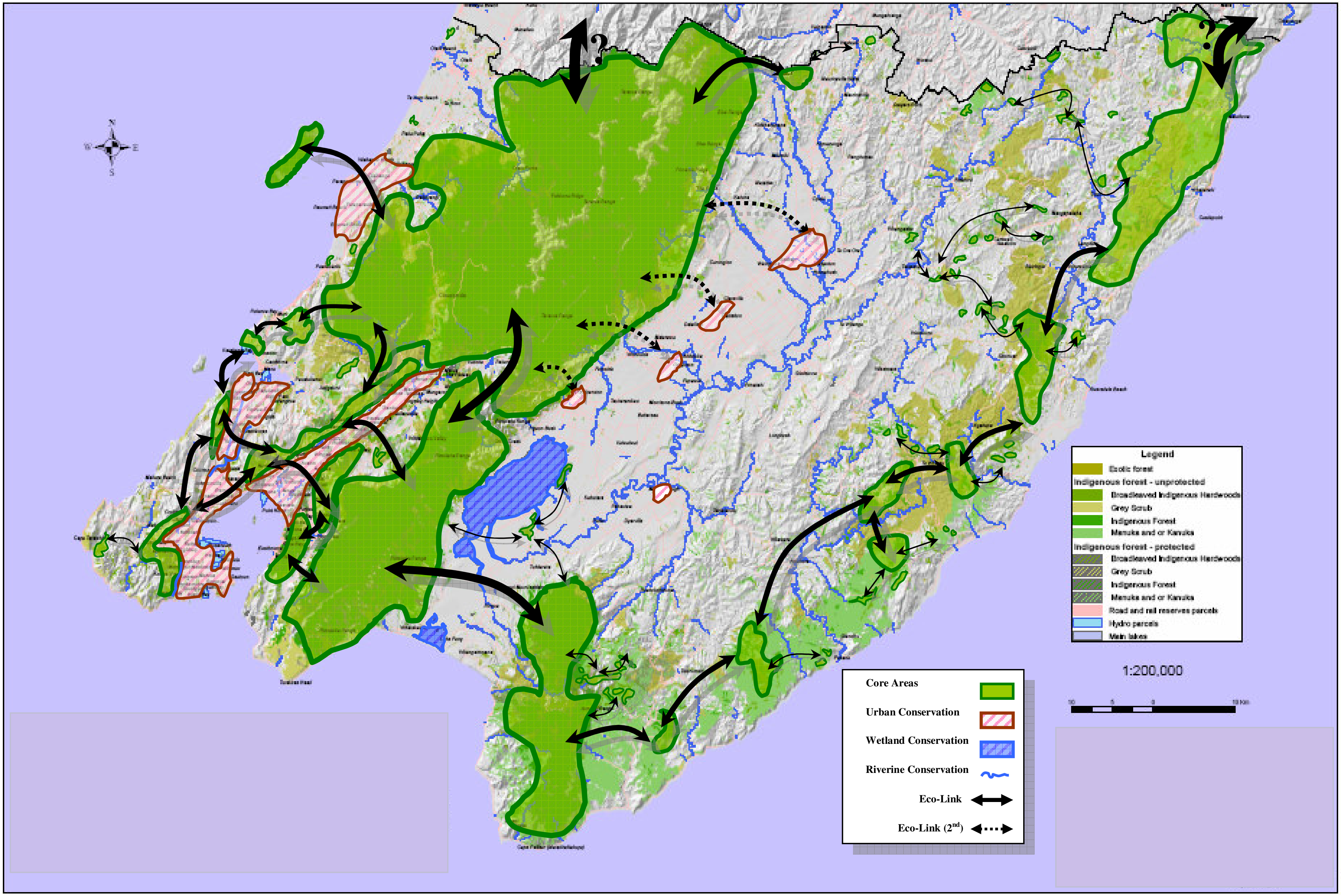
Biodiversity specialists familiar with Wellington region on whom the Ecological Network Map and Strategic Biodiversity Map were tested for validity.

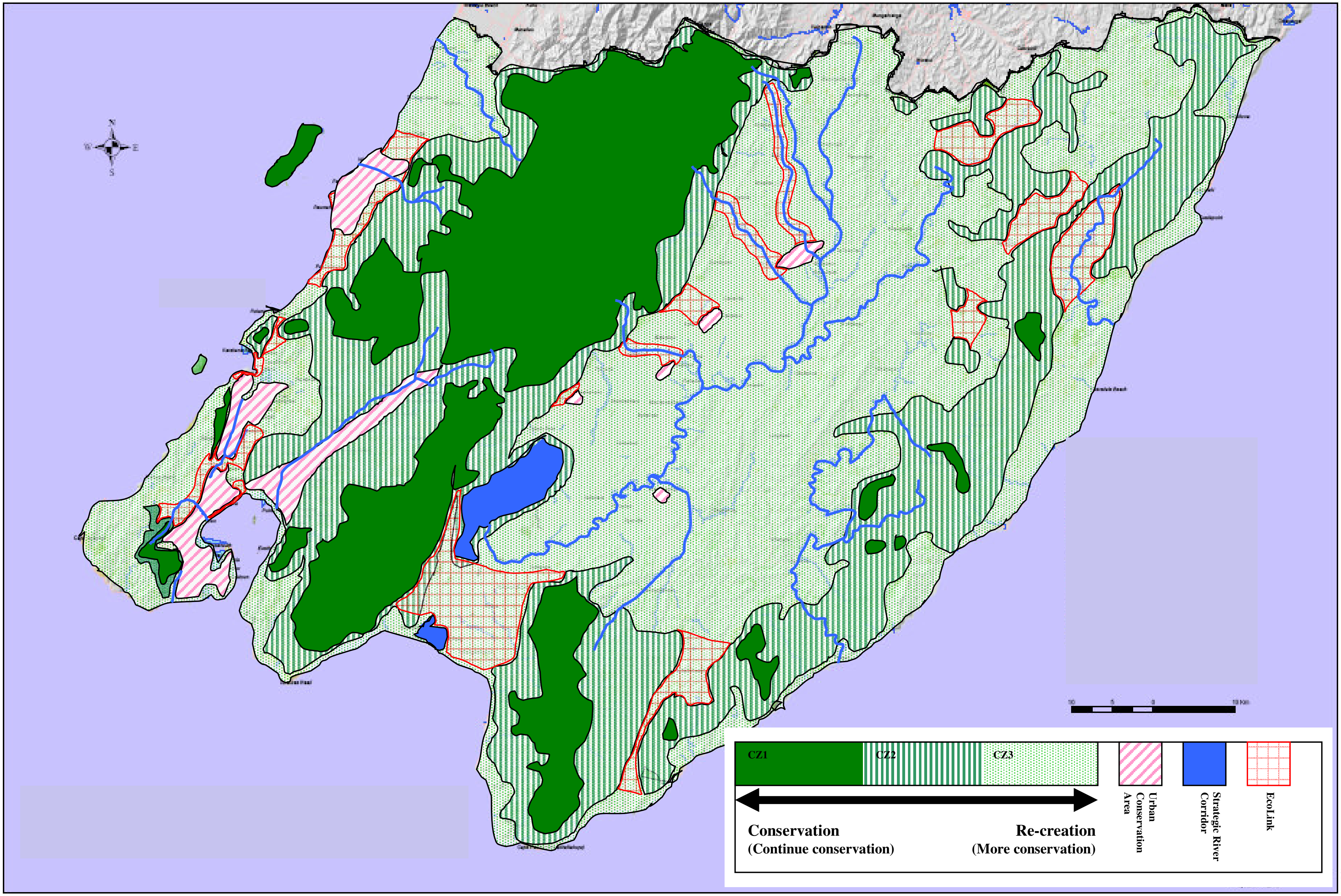
Name	Position/expertise	Agency
Crisp, Philippa	Ecologist	GWRC
Flavell, Jeff	Conservation Planner	DOC Wellington Conservancy
Forman, Richard	Professor of Landscape Ecology	Harvard University, Boston
Miskelly, Colin	Senior Biodiversity Tech Advisor	DOC Wellington Conservancy
Park, Jeff	Ecologist, conservation historian	Ex-DOC, consultant
Porteous, Tim	Biodiversity Coordinator	GWRC
Ogle, Colin	Botanist	Ex-DOC
Simpson, Phillip	Ecologist	Ex-DOC, consultant

APPENDIX J – BASE LAND COVER MAP FOR WELLINGTON REGION



APPENDIX K - REGIONAL ECOLOGICAL NETWORK for WELLINGTON REGION

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CZ1
CZ2
CZ3
Conservation
(Continue conservation)
Re-creation
(More conservation)
Urban Conservation Area
Strategic River Corridor
EcoLink

APPENDIX M – STRATEGIC SPATIAL POLICY AND OBJECTIVES for BIODIVERSITY MAP (Source: Catchpole, 2006:26-27; Noss & Cooperrider, 1994:174-177)

Zones		Biodiversity Characteristics	Policy Development	Policy Implementation
HABITAT CONSERVATION, ENHANCEMENT & RE-CREATION AREAS	CZ1	**CORE AREA** Protected indigenous forest	Recognise and seek to maintain &, where necessary, restore the biodiversity resource	Decisions should ensure the maintenance & restoration of the integrity of the biodiversity resource • Pest management • Minimise roading • Limit tracks • No off-road vehicles or mountain bikes. • Land acquisition or covenant programs • No grazing • No resource exploration or mining • No commercial plant collection etc • Hunting only as authorised • Tramping, environmental education & research
	CZ2	**BUFFER ZONE** Unprotected indigenous & exotic forest Multiple use	Recognise role of buffers & ecological networks in: • protecting core • additional habitat • Climate change adaptation Strengthen their integrity by expanding core & patches of high quality habitat & enhancing connectivity Seek strategic habitat restoration	Decisions should expand & enhance networks & strengthen them through strategic re-creation of habitats • No logging of primary forest where possible • Limited new roading • Reduction of road density, except where necessary to operate private land • Covenants & management agreements with private owners • No off-road vehicles on public lands • Pest management on pubic lands • Protection & restoration incentive programs • Promote vision of multi-purpose, integrated landscape
	CZ3	**ECOLOGICAL RE-CREATION ZONE** Developed landscape High quality habitat restricted to isolated sites, separated by large areas of farmland &/or rural urban areas	Recognise & protect isolated biodiversity features & encourage their expansion Recognise ecological networks & the need to reconnect and re-establish a functional ecological landscape	Decisions should protect remnant biodiversity features & seek opportunities to expand, buffer and reconnect them, thereby providing increased protection from external impacts. • Protect riparian corridors • Moratorium on development in all natural habitats, instead channelling development into already developed or degraded areas • Use transport corridors, shelterbelts & river corridors to increase habitat & reconnect the ecological landscape • Restoration projects, both short and long term • Public education programs • Establish community biodiversity partnerships • Establish protection & restoration incentive programs
	ECOLINK (CORRIDOR)	**SPECIAL RESTORATION AREA** Priority potential connectivity 'corridors' in currently developed or threatened agrarian landscape	Encourage re-creation & restoration of multi-functional, semi-natural habitats. Recognise the need to reconnect the ecological landscape through developing corridors & stepping stones through a mixture of roadside, riparian & fenceline planting of appropriate native-friendly plants	Decisions should allow for restoration of multi-functional, semi-natural habitats. Consider tools such as • Promote vision for functional landscape • Shelterbelts, river & transport corridors to increase habitat & reconnect the ecological landscape • Encourage protection & enhancement of indigenous remnants as basis for habitat and stepping stone linkages • Initiate restoration projects, both short and long term • Build stakeholder and community partnerships • Provide plants free or at-cost for target areas • Encourage community restoration groups
	URBAN CONSERVATION AREA	**URBAN CONSERVATION AREA** Dominated by built environments, and isolated patches of exotic & regenerating native vegetation of various sizes	Recognise habitat value and potential of urban area & protect existing biodiversity resources	Decisions should protect & enhance existing remnants and encourage development of new habitat through a mixture of: • Promoting vision for urban biodiversity • Identify, protect or restore urban ecological components – core, linkages, buffers • Subdivision control – retain & enhance native vegetation, education on plant and animal pests, structure plans • Urban education programmes • Encourage community restoration groups • Establish protection or restoration incentive programs (e.g., provision of plants free or at-cost for target areas, etc)
	STRATEGIC RIVER CORRIDOR	**RIPARIAN AREA** Region's core river & floodplain resources & role as existing or potential strategic habitat corridor	Recognise & seek to maintain & restore the biodiversity resource & critical role as ecological corridors & provision of ecological services	Decisions should ensure the maintenance &, wherever possible, restoration of the functionality and environmental services of the biodiversity resource. This will include protection &, wherever possible, the recreation of suitably planted riparian strips while avoiding obstruction of river. A buffer (fenced) zone around significant lakes (viz Lake Wairarapa)