DEVELOPMENT OF A STRATEGIC PLANNING FRAMEWORK FOR THE RESTORATION OF INDIGENOUS HABITATS ON THE MANAWATU PLAINS

DRAFT

DISCUSSION DOCUMENT

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Table of Contents

Figures

Tables

Development of a Strategic Planning Framework for the Restoration of Indigenous Habitats on the Manawatu Plains

Executive Summary

Introduction and Problem statement

Natural habitat in New Zealand, despite the system of protected areas and national parks continues to be under threat. Not only is insufficient land covered by protective mechanisms but also much of what is 'protected' remains threatened. One of the critical problems in conservation is that due to resource constraints and other pressures, such as the need for land for farming and exotic forestry plantations, it is possible to conserve only a small proportion of natural areas, focusing on the 'best' and/or the most threatened. Looked at strategically this often means that what is conserved is a patchwork of fragmented habitats with few links to other comparable habitats and thus arguably of limited ecological validity. It is a problem that faces conservation not only in New Zealand but internationally. In Europe and in the USA there is a growing body of research looking at bio-regional planning and the need for adopting a strategic approach to the allocation of land for conservation. In practical terms mechanisms need to be developed at the strategic level in order to overcome habitat fragmentation, one such mechanism that is finding increase support internationally is the greenway/ ecological corridor approach.

Research Brief: Manawatu

In New Zealand, particularly on the coastal plains where the landscape is characteristically intensively farmed, habitat fragmentation is a major concern for conservationists. It is a major concern for conservation in the Manawatu Ecological Region where very little remains of the original natural vegetation and what is left is generally confined to fragmented and often threatened habitat patches. A research programme was undertaken in the Manawatu Plains Region to explore and develop a strategic or bio-regional planning framework to address and provoke discussion on problems resulting from habitat fragmentation.

To develop the bio-regional framework the following were undertaken:

- an examination of the strategic distribution of ecologically valuable areas (those protected and to a lesser extent those falling outside protected area designations)
- identification of critical areas for conservation, including both corridors and core habitat areas and an exploration of ways of maximising linkages and potential linkages between areas of natural habitat
- the development of a spatial bio-regional conservation plan for the Manawatu plains area

Data and methodology

The primary data sources used to locate and identify natural areas were the Protected Natural Areas reports and the Conservation Management Strategy Surveys. Extensive field visits were undertaken to locate and assess both documented natural areas and other natural areas not included in the Protected Natural Areas reports and Conservation Management Strategies but which nonetheless could be important contributors to any future corridors. The focus in examining the sites was to evaluate their geographical context and their potential role in the broader ecological network, rather their current ecological status. The Geographic Information System, ArcView supported by ArcInfo was used to map natural areas and to identify potential ecological corridors. Ecological corridors were identified using the following criteria:

- number and size of existing natural areas
- quality and size of natural areas
- distribution of natural areas
- position within the broader ecological landscape
- proximity to key natural corridor features
- need/ priority.

Substantial areas of natural vegetation which could be used as the basis for corridor development were not present in the Manawatu Plains. The corridors proposed in this research therefore, are potential future corridors rather than existing corridors. In addition to the corridors there are some good habitat patches which can be developed as core habitats. These comprise remnants and associated natural vegetation which could act as a focus for regeneration through consolidation of the remnants by judicious planting and the application of methods designed to safeguard and enhance their existing and potential conservation value. A strategic network of potential corridors and core habitat areas for the Manawatu Plains is therefore proposed. These proposals are to be circulated for discussion with both planners and various conservation and land use experts for consideration, and will be amended accordingly.

Looking Forward

The practical implications of instituting a network of corridors and core habitats are not to be underestimated. At no stage was it envisaged that the proposed network would be implementable in the near future. What was envisaged are proposals that will initiate discussion and thinking on the development of ecological corridors at the strategic level and the role conservation planning can play in developing such corridors. There has been minimal research done in New Zealand on the development of ecological corridors at a bio-regional or strategic level. Hopefully this document will be a catalyst in furthering discussion, and focus attention on the restoration and rehabilitation of indigenous habitats on the Manawatu Plains which represent a unique but undervalued part of New Zealand's natural heritage

Development of a Strategic Planning Framework for the Restoration of Indigenous Habitats on the Manawatu Plains

Introduction

In New Zealand, particularly on the coastal plains where the landscape is characteristically intensively farmed, habitat fragmentation is a major concern for conservationists. This discussion paper presents the findings of research conducted in the area between the coast and the mountain ranges in the western part of the lower North Island. It identifies, using a geographic information system, a strategic network of potential green corridors which can be used as a basis on which to develop a bio-regional ecological planning framework. The framework seeks to provide a framework for the restoration of indigenous habitats in an area characterised by highly modified landscapes, a multiplicity of institutional and conservation frameworks and with different cultural environmental understandings. The research is presented in two parts. Part one examines the theory and applications of the corridor concept to habitat restoration. The second part focuses on the field research undertaken on the Manawatu Plains.

Part I

Development of the Corridor Concept and Potential Applications

The emergence and development of the corridor concept

Green networks are a familiar concept in planning although the terminology used i.e. 'networks' and 'corridors' is of more recent origin, emerging in the 1950s. Frederick Law Olmestead one of the pioneers of American planning is general accepted as the first proponent of greenways (Fabos, 1995 and Smith, 1993). He incorporated linear open spaces into his designs for Berkley and Oakland in the 1860s and later in the late 1870s in designing the now well known Emerald Necklace linear park network in Boston. The purpose of these linear spaces was twofold, to improve drainage and water quality but more significantly for social and recreational purposes. There was no intention that they perform an ecological function. Similar developments occurred, though to a lesser extent in Britain and the in newly developing towns of Australia and New Zealand. In Britain there was a de-facto development of linear or perhaps more accurately 'linked-open spaces'. Planned open spaces were evident in a number of the major cities. In central London there remains a network of inter-linked parks, namely, Hyde Park, Green Park and St James Park, and in central Paris where the Bois de Bolougne, links via the Seine River to other parks such as Ile de Puteaux, Parc Suzanne Leglen, Champ de Mars and Jardin des Tuileries. De-facto linear open spaces were also developing in the 1800s along canal networks and the railway lines. Whilst originally constructed for industrial transportation purposes like a number of transport corridors the Leeds Liverpool canal in the north of England, has over time developed nature conservation values and is now in parts classed as a site of special scientific interest on account of its wetland ecology.

In the formal planning sphere linear open spaces continued to be proposed. At the turn of the century proponents of new forms of town planning such as Ebeneezer Howard incorporated a linear ring of accessible open space into his 'garden city'. It is a theme that still resonates in contemporary plans for new settlements. Some 50 years after Howard, Patrick Abercromie proposed the still strongly supported idea of green belts around major cities. Later British new towns such as Redditch and Warrington continued the process of incorporating a combination of parks and linked walkways into town design. Only in the most recent new town developments such as Warrington, though, was ecological function as well as recreation a major consideration.

Closer to home the role of Australia and New Zealand in green network design has been overlooked by most planning historians and corridor proponents. The provision of town belts was a guiding principle in the design of cities such as Dunedin, Wellington and Adelaide??/Melbourne??. These town belts pre-empted similar developments in Britain by nearly a century. Wellington's green belt was designated in 1841?, Dunedin's in the 1870s and both remain substantially intact. Again whilst ecological function was not the guiding factor in their design, almost by default some indigenous vegetation survived in these natural landscapes. In the 1990s these town belts, despite pressures of development over the years, remain largely intact, and contain important patches of indigenous vegetation. They also present excellent opportunities for developing ecological corridors.

From networks to ecological corridors:

The USA

The development of corridors for primarily ecological functions was a relatively recent development with somewhat parallel developments occurring in both Europe and North America. In America a significant force in the development of ecologically based planning, was McHarg's now classic 'Design with Nature' in which he stated "The distribution of open space must respond to natural process...The problem lies not in the absolute area but in distribution" (1965, p.65). Though McHarg did not specifically identify ecological corridors the techniques he applied clearly recognised the importance of ecological linkages as they related to watersheds, waterways, coastlines and other ecologically valuable. These habitats were identified as having ecological functions which outweighed their development potential. His method which used overlay type techniques was a forerunner of techniques now used in geographic information systems. Developments more directly related to corridors in the USA included those associated with riverine environments. In 1968 the National Wild and Scenic Rivers Act was passed, which, further supported by the Clean Water Act offered protection to wetlands and river corridors (Smith, 1993, p. 8). More directly concerned with corridors have been numerous developments aimed at providing and enhancing recreational greenways. The President's Commission on

Americans Outdoors proposed a national system of greenways in which "we have a vision for allowing every American easy access to the natural world...They will connect parks and forests and scenic countrysides, public and private" (in Smith, 1993, p.9). Greenways are thus an important and increasingly common multi-functional landscape element in the USA.

Britain

In Britain the development of the corridor concept has been less precise but possibly more ecological, with the term wildlife corridor being commonly used. There is no universally accepted point at which corridors came to be recognised, but the publication of Teagle's (1978) 'The Endless Village' was certainly important. Teagle conducted ecological surveys of natural open space in the Black Country, a declining industrial conglomeration set in the middle of England and an area not noted for its naturalness. In the book Teagle likened the Black Country to a collection of settlements (endless villages) linked by a series of natural spaces, many of which abounded in wildlife. These linkages comprised in the main railways, canals, rivers and derelict land and were found in ecological surveys, to be surprising rich in wildlife.

The 1980s in Britain saw a meteoric rise of interest in urban wildlife as the 'overlooked' and taken for granted natural habitats (many still being lost in the economic development boom of that time) became the focus of an urban wildlife movement. Nature Conservation groups championed the cause of urban wildlife in cities across the country. Wildlife strategies were produced, starting with the West Midlands Nature Conservation Strategy in 1984 (West Midland County Council, 1984). This early strategy in which 'open space corridors' and wildlife links (called stepping stones) were identified acted as a forerunner for the ongoing production of ecological strategies by local authorities. These strategies have become increasingly used by planners, with the corridors identified in these strategies (Figure. 1) and their associated policies frequently being incorporated into statutory planning documents such as Unitary Development Plans.

Figure 1. Wildlife Corridor Policies as developed for the city of Leeds, England

3.6.5 **Interruption, destruction or degradation of existing linear habitats and wildlife corridors will be strongly resisted.**

Links with the Green Belt and major wildlife 'reservoirs' will be strongly protected and improved.

Where linear habitats or wildlife corridors are unavoidably damaged or degraded, alternative links will be quickly investigated and established.

3.6.6 **Wherever possible the network of linear habitats and wildlife corridors will be extended and enhanced.**

Habitat "islands", such as isolated woodlands, will be linked and incorporated into the City's wildlife network, wherever possible.

Built-up areas need not block wildlife corridors; these areas can be ameliorated by measures such as those outlined in paragraphs 3.5.6 to 3.5.8.

Australia

The focus of conservation activities in Australia as described by Bennet (1990) has strong resonance for New Zealand:

> The traditional approach to nature conservation in Australia has been to identify areas of high conservation value and set them aside as reserved areas... Less attention has been given to wildlife in large areas not reserved for nature conservation, particularly the agricultural and pastoral lands (p.25)

In recent years, however, there has been the development of substantial interest in addressing fragmentation issues (Gilfedder and Kirkpatrick, 1995; Saunders, Hobbs and Arnold, 1993). A significant early work on corridors was, *Nature Conservation 2; The role of corridors*, (Saunders and Hobbs, 1990) which explored issues such as corridor rehabilitation, criteria for corridor designation, corridor width, GIS and biological modelling, edge effect of corridors, management of corridors on private land, urban corridors and weed movement along corridors. In recent years there has been increased attention given to conservation at the strategic level through the application of bio-regional planning approaches. The view expressed by Bennet (1990) that " strategic planning is required to establish coordinated regional systems of linkages and corridor networks...[with] planning on a regional basis..." (p.30) is one that is finding increased support in Australia. A substantial body of research which addresses bio-regional planning issues is accumulating as indicated in the work of Powell (1993) on the Murray Darling Basin, and the 'biogeographic regionalisation' project of Thackway and Cresswell (1995). The Australian local government Association supports bio-regionalism through its production of guidelines for the development of Regional Environmental Strategies. Bio-regionalism and corridors are thus a key element in Australia's developing biodiversity plans at both national and regional level.

The approaches taken to corridors development, their function and design reflects these differing origins. The multifunctional character of the USA greenways movement and the strongly urban orientation of the British approach have influenced both corridor theory and design. Australia has adopted a wider approach with corridors commonly being part of a broader bio-regional conservation planning. The 1990s then sees ecological corridors as a commonly used and relatively well understood conservation planning tool. As corridors become increasingly used further attention is being devoted to discussion of the functions of corridors and how their design can be used to enhance their ecological attributes.

Corridor Definitions and Functions

Ecological corridors are linear habitats that either link one or more patches in a landscape or in themselves comprise isolated linear shaped habitats. Corridors occur where landscape has been subject to modification and originate in a number of ways namely:

- *Natural corridors*: such as streams or dune ridges and are the result of natural environmental processes
- *Remnant corridors*, such as strips of natural grasslands left in between forest plantation blocks: forest remnants left in gullies or on river terraces after clearance for sheep farming (common in New Zealand)

- *Regenerated corridors*: occur as a result of re-growth of a strip after clearance such as re-growth of reeds on riparian margins cleared for grazing but which prove too damp for grass to thrive
- *Planted corridors*, such as hedgerows, shelter-belts and recreational greenways
- *Disturbance corridors*: railway lines, road verges, and cleared transmission line strips. [after Forman and Godron, in Bennett, 1990, p.3]

Function is a prime consideration in the design and development of green corridors. For example, a corridor designed specifically for ecological purposes such as to facilitate the upstream migration of a particular fish such as the rare and endangered short jawed kokupu will be designed to provide suitable riparian and in stream habitat and to remove obstacles and disturbance that could impede upstream movement. The same river designed as a multi functional landscape, may encourage recreational use of the river through boats, riverside walkways, esplanade reserves, and support the development and maintenance of game fishing, all of which may conflict with the needs of the short jawed kokupu. Corridors therefore, fulfil a range of functions they can:

- provide areas of natural habitat
- conserve a representative sample of a region's natural heritage
- support the dispersal of plants and animals into surrounding areas
- function as conduits for the movement of animal and plant species
- complement and support natural landscape processes and patterns
- provide a focus for and to support restoration
- provide multifunctional green spaces

The next section focuses on designing corridors which support ecological functioning.

Ecological corridors: design criteria

Corridor design is dependent on both the function the corridor has to perform and the landscape context within which the corridor is located. Rather than identify all the criteria associated with corridor design only key elements are discussed here. For specific design criteria refer to Figure 2 'Guidelines for Wildife Corridor Design'. Central to understanding of corridors is 'Island biography' which contributes significantly to understanding the principles of corridor design. The theory basically states that habitats will support greater numbers of species if they are near to other sources of possible colonists. 'Island faunas' thus, become progressively impoverished the further they are from the nearest large habitat patch. Secondly, the larger the habitat patches, the more species they are likely to support. Size alone though, is only a partial guide as shape is also extremely important as single large patches tend to hold more species than a number of smaller patches of equivalent size. Similarly, circular patches tend to support more species than patches of equal area with a linear shape. The reason for this is that the larger the area that can be defined as 'edge' the larger the area of disturbance and linear shaped patches have a greater proportion of edge habitat. Edges are particularly vulnerable not only to climatological factors such as exposure to sun, wind, cold, but also to invasive species, pollutants, noise, and human activities. Thus, for example a deciduous forest remnant of 1 hectare will be entirely edge habitat compared to a 100 hectare forest remnant which would only have 19% edge habitat (Collinge, 1996, p.64).

Figure 2: Guidelines for Wildlife Corridor Design [after Noss, 1993]

Applicable at any scale

- Design and manage for native biological diversity
- Planning unit should be the minimum area necessary to ensure demographic and genetic survival of the species (see North Westland Wildlife Corridor example, Figure 3)
- Do not allow greenways or other corridors to substitute for the protection of large intact nature reserves
- Do not allow greenways to divert attention away from managing the landscape as a whole in an ecologically responsible manner

Selecting Alignments

- Link habitats that were connected in pre-settlement landscapes with greenways of similar habitats
- Identify and make use of naturally existing movement corridors
- Emphasise connection of habitats whose species are fragmentation sensitive
- Use wide greenways to allow for long range migration of species
- Avoid greenways that lack substantial nodes of habitat at suitable intervals
- Include a range of habitats
- Avoid roads and other potential barriers
- Manage the landscape matrix to function as a corridor by providing continuity of habitats with natural vegetational structures
- Design a network of multiple corridors linking habitats to provide redundancy and multiple movement pathways

Setting Widths

- Make greenways wide enough to minimise edge effects
- Determine width according to the needs of the most sensitive species
- Interior should be wide enough to accommodate the needs of the most sensitive species
- Incorporate the highest quality habitat possible for the most sensitive species within the greenway boundaries

Preparing Site Designs and Management Plans

- Develop a management plan to maintain or restore native vegetation with emphasis on habitats used by the most sensitive species
- Where roads cannot be avoided design safe road crossing methods (e.g. toad and deer crossing tunnels)
- Control access and human use of corridors to protect species sensitive to disturbance
- Seek zoning regulations or landowner agreements to control adjacent land use
- Manage narrow corridors lacking interior habitat to encourage and maintain vegetational complexity

In New Zealand the concept of edge is a crucial one as most of New Zealand's fauna and flora developed in forest conditions and are thus extremely vulnerable to edge effects. A large area of edge habitat can facilitate colonisation of the habitat by invasive exotic species. The aim then in corridor design must be to retain as many large habitat remnants as possible, to provide links between remnants (to overcome the problems associated with island habitats) and to develop restoration strategies that not only increase the total area of natural habitats but reduce possible edge effects.

Another major design consideration is that of scale. To date most corridor design work has been at local scale focusing on the development of links at city or neighbourhood level. A more recent development and one that takes corridor design to a new level is that of bio-regional planning.

Bio-regional or Strategic Planning for Corridors

There is growing recognition that to be successful conservation must embrace the whole landscape not just confine its efforts to areas designated as reserves. The key, therefore, is to link the reserved and non-reserved landscape. New Zealand has set aside a comparatively large proportion of its land area for conservation purposes through designating areas as national parks, scenic reserves, and wildlife management reserves. In doing so, New Zealand could and to a large extent has sat back thinking that the focus of its conservation efforts now needs to be directed at maintaining and enhancing the biodiversity of those reserves. Whilst these efforts are necessary and justifiable they are not all that is required. Reserves on their own will never be able to ensure the long-term viability of a country's biodiversity and natural landscapes.

Reserves are selected on the basis of ecological importance and quality as well as for practical reasons. These include practical reasons such as ease of acquisition, the need to protect the habitat from some type of threat usually development, or conversely because they occupy land with the least developmental potential, strong advocacy on behalf of the habitat, aesthetic, cultural or other reasons. This somewhat random element in the selection process can clearly be seen on some of the Department of Conservation (DoC) owned sites which have minimal ecological merit as they comprise exotic amenity grasslands. These sites usually were gifted to DoC and thus form part of DoC's conservation estate. There are then a number of weaknesses associated with a reserve only system which can be identified: These include the following:

- Protected areas will never be large enough to maintain all biodiversity
- Maintenance of current diversity and habitat is supported by the unreserved matrix (i.e. landscapes outside the reserves, this is most noticeable with wetlands which can dry up as a consequence of abstraction processes occurring on the unreserved surroundings)
- Species for whom the reserve is intended do not recognise reserve boundaries
- Confining conservation to reserves can give the message that 'non reserved' land has no conservation value
- Reserves suffer from isolation and need to be linked or have access to other habitats for dispersal and regeneration processes to occur

Figure 3: North Westland Wildlife Corridor

The most well developed large scale corridor programme in New Zealand is The North Westland Corridor programme. The priority in developing the corridor programme was to help maintain the rainforest bird populations which were seen as threatened by beech timber logging activities. The corridor first proposed in the 1970s was to consist of a network of linked forest reserves and aimed to provide the only forested link not broken by large rivers between the Paparoa range and the outlying ranges of the Southern Alps (O'Donnell, 1991). A 1978 government moratorium on logging was applied to most reserves but excluded corridors, where logging continued. Nonetheless, the impetus to develop corridors continued. In 1986 the Wildlife Service resubmitted the North Westland corridor proposal to the government's advisory committee on reserve proposals and subsequently to the Government working party on West Coast forests. In 1986 the West Coast Accord was signed by Government and would

- Establish proposed reserves and wildlife corridors
- Provide sufficient productive zone indigenous forests for logging until replacement exotic species were available.

The North Westland Wildlife Corridors were then allocated to the Department of Conservation and a research programme initiated to assess the relationship between logging and wildlife corridors. Only birds were considered in the corridor proposals and the study recognised that the effectiveness and values of the corridor are likely to differ according to species. The study concluded that:

- The protection of habitat and habitat continuity is a necessary but not sufficient condition for the survival of threatened species
- Habitat discontinuities and constrictions within the corridor should be rectified as far as is possible for corridors to function to their fullest potential
- The current legal status of wildlife corridors does not adequately recognise the high conservation values present
- The corridors are at a larger scale than elsewhere because the species most at risk (kaka, yellow crowned parakeet and great spotted kiwi) have large area requirements
- A minimum of 3-5 kilometres width was seen as necessary to reduce edge effects
- Logging is incompatible with the protection of threatened species in the North Westland region [after Overmars et al. 1992]

The North Westland Wildlife Corridor indicates the complexity and lengthy process associated with developing corridors even in a relatively undeveloped part of New Zealand, which contains high proportions of indigenous habitat (approximately 80%, New Zealand Biodiversity Strategy, 1998). Despite the fact that the North Westland Corridor represents possibly New Zealand's most significant effort at developing a bio-regional corridor the future of the corridor is far from assured as despite widespread opposition, logging in the area, still continues.

Recognition of the limitations of a reserve based conservation approach leads to the question of how can the reserve system be enhanced and what other conservation approaches need to be developed? It is here that the potential of bio-regional planning becomes evident. Bio-regional according to the World Resources Institute (1992)

> "defines a context for conservation management... It involves identifying regional priorities for conservation while encouraging local action and ownership of the conservation process ...It requires an integrated approach to management"

It promotes therefore, the development of ecological planning at a scale which recognises the supremacy of 'natural units over other jurisdictional areas, including political divisions'. It allows the range of landscapes, their inter-relationships and distributions to be assessed in a more ecologically coherent way. Fundamental to the bio-regional planning process is the development of a strategy which sets out a vision for the future. A bioregional planning approach was followed in the development of the North Westland Wildlife Corridor, to date New Zealand's largest corridor planning project. It was this need to develop a comprehensive strategy at the bioregional level which prompted the Manawatu research. In the Manawatu Ecological Region in common with other ecological regions the reserve approach predominates with limited attention paid to how these reserves relate to each other and to the unreserved matrix. Minimal consideration has been given to how the major ecological reserves, in this case the Tararua and Ruahine Forest Parks interact or could interact with the fragmented bush remnants and other remaining natural habitats on the coastal plain.

Bio-regional planning and the contribution of geographic information systems

When McHarg wrote his seminal work 'Design with Nature' the overlay process he used to illustrate potential conflicts of interest between natural landscapes and development demanded laborious preparation of coloured overlay maps. Nearly thirty years on whilst McHarg's principle message to planners to 'design with nature' remains just as relevant, the methods he used to demonstrate potential outcomes are obsolete. McHarg himself recognised the huge potential offered by the developments he rightly foresaw in computerised mapping. Computerised mapping or Geographic Information Systems (GIS) offer major benefits to corridor development and analysis. GIS has the capacity to:

- more easily collect, collate, assess and share ecological and geographical data on a large scale (especially valuable in bio-regional planning).
- utilise and integrate different types of data such as remote sensing and satellite imagery
- simulate and/or model alternatives and potential outcomes, even very simple models have the capacity to generate important predictions
- to integrate different types of land use data in corridor analysis,

- to represent and extrapolate significant biodiversity and landscape trends and scenarios
- to model alternative corridor locations and designs
(after Norton and Nix, 1991).

GIS depends for its success on the quality and scope of the base data on which it develops and models the conservation proposals. In New Zealand the need for better environmental data was a problem identified in the State of the Environment Report; "New Zealand's environmental information needs considerable upgrading if the state of the nation's environment is to be accurately described and trends detected (Taylor and Smith, 1997, 10.3). One of the problems that effects conservation research is that habitat and natural areas data is not comprehensive, co-ordinated or standardised and exists in a wide range of institutions and types. In conducting the Manawatu Research for example, data on sites of natural habitat were held by DoC Wellington, DoC Wanganui, voluntary organisations, councils, and in both published and unpublished research reports. Data was not necessarily standardised, (a particular problem when for example trying to examine long term trends in species numbers), was incomplete and there was no inventory stating what data was held, where and of what type.

The government has recognised that inadequate data is a national and not just a local problem. The research institutes, the Ministry for the Environment and the Department of Conservation are devoting considerable effort towards developing standard methods of classifying and measuring the status of New Zealand's biodiversity. GIS is being used to represent much of this data. DoC has developed a national GIS inventory for its sites, though progress on developing more localised GIS data bases and species records does differ significantly in different conservancies. The Crown Research Institute Landcare has already developed comprehensive GIS based land use maps for the whole country.

The role of the Planning Profession in corridor and green network development

Bio-regional planning demands co-ordinated planning from local and regional governments and organisations, particularly conservation organisations. Allocation and sourcing of resources and data exchange are just two of the many issues that will have to be addressed through multi-agency co-ordination if bio-regional planning is to work. Further the development of corridors necessitates the unified efforts of a number of professions, primarily; ecologists, landscape architects, leisure mangers, planners and possibly engineers. Whilst ecologists and those with conservation knowledge are vital in identifying areas with existing or future ecological value it requires the implementation of planning processes to give these areas the protection necessary for their conservation and development. The tools that are available to planners working towards the protection and development of areas with ecological and or recreational potential are threefold;

- legislation
- plans both statutory and non statutory
- the planning system (mainly through the development control process).

In no New Zealand legislation are corridors or networks per se given mention. Corridors are only addressed through the application of biodiversity (mainly reserve) and amenity references. The primary legislation in this regard is:

- The Conservation Act: passed in 1987 the Act operates in conjunction with several other acts (e.g. the National Parks Act 1980, Reserves Act 1977 and the Wildlife Act 1953) and charges the Department of Conservation with directly protecting the natural environment on 30% of the land area, and advocating its protection elsewhere (Taylor and Smith, 1997, p.8.78). The Act therefore focuses on conservation measures proposed for Crown land.
- The Resource Management Act: passed in 1991 is New Zealand's key planning legislation. The Act requires that land resources be sustained, that outstanding natural features and landscapes be protected from inappropriate development, the protection of areas with significant vegetation and habitats and to have particular regard to amenity values. The Act relates only to private land and has little effect on crown land.

In addition to legislation planners also have recourse to key government policy statements and initiatives which do not carry the statutory weight of legislation but still have to be considered in planning policy and practice. These actions, include management agreements (particularly relevant in forestry), international agreements to which New Zealand is a signatory such as the Biodiversity Convention, key policy and discussion documentation significantly, the *Environment 2010 Strategy* (MfE, 1995), *State of the Environment Report 1997* (Taylor and Smith, 1997), and most recently *New Zealand's Biodiversity Strategy* (DoC/ MfE, 1998).

Planners have to have regard to legislation but it is through development plans and the resource consent process that planners mostly influence conservation practice. There is no requirement for planners to set aside land to develop policies relating to corridors in the way that they must for reserves. The legislation does, however, refer to esplanade reserves and esplanade strips which have functions relating to improving water quality and enabling public access along the sea, rivers and lakes, where such use is compatible with conservation values (RMA, section 229)

For corridor development in general to be supported through planning demands that planners both understand and support the corridor concept. To date, few planners would have come across corridors through either their training or work experience. An education programme within planning is required to rectify this situation. In the United Kingdom there is greater reference to corridors in plans and planning documents than in New Zealand. Corridors are commonly indicated on development plans together with their associated policies. Progress in integrating the concept of corridors into plans or resource consent decisions in New Zealand has been extremely limited. Nonetheless in the few cases where corridors have been integrated these have been remarkably effective in drawing the attention of the public, conservation and other organisations and government departments to the need for ecological links.

When attempting to develop corridors planners will confront obstacles (see Table 1). The system of private land rights and the widespread antipathy of farmers as the major land owners to designation of parts of their land for conservation purposes, can [present problems. Designation of land for conservation purposes is often perceived as removing from landowners the right to use their land as they wish and thus as reducing the economic potential of their land. Consequently, any corridors proposed for privately owned land, especially farm land will inevitably meet opposition. Planners will therefore, have to give considerable attention to ways of reducing potential opposition and gaining support for corridor proposals. One authority which has been able to overcome these obstacles and which has managed to develop corridors furthest is Waitakere (see figure 4).

The Waitakere City Plan identified the benefits associated with designating corridors as follows:

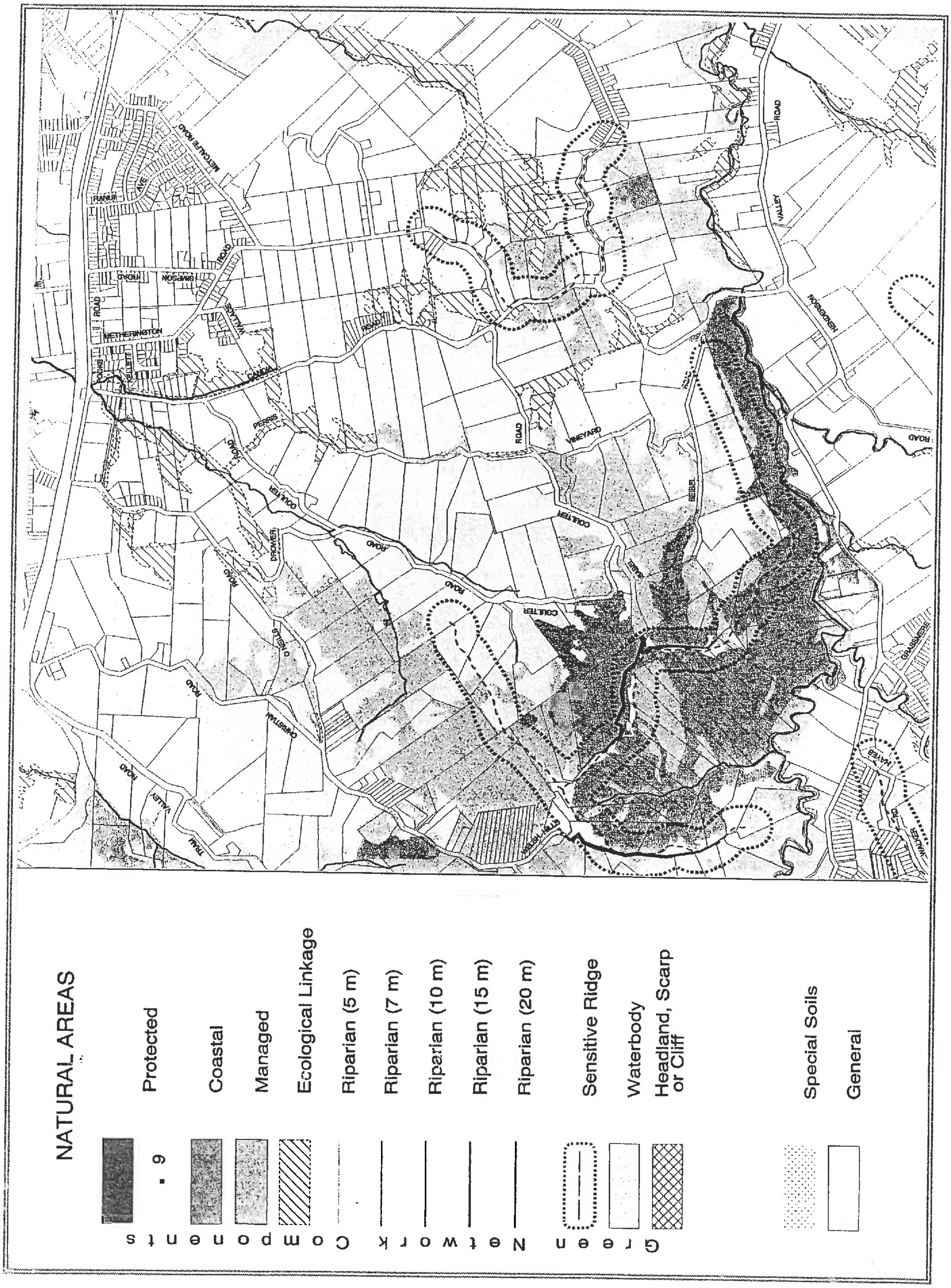
- Land can be set aside for corridors
- Policies and rules can be developed to protect and enhance corridors
- Where land can not be set aside policies can be identified for land seen to be performing corridor functions and appropriate policies developed
- Corridors can be developed at a strategic level to cover larger areas
- Links can be created between significant habitats on crown and private land

The public consultation process associated with the planning process allows for promotion of the corridor idea.The success of Waitakere in developing corridors stands out in a sea of plans faltering on the rocky ground of conservation in New Zealand. Plans which have failed to be approved due to opposition to conservation proposals include: the Wellington Landscape Plan, the Far North District Plan (which had farmers protesting on the streets) and the early version of the Queenstown District Plan. Waitakere's success was due to a number of factors several of which were peculiar to Waitakere but all of which are worthy of note for any planners seeking to develop corridors elsewhere:

- Waitakere has a strong history of supporting conservation
- Waitakere prides itself on its 'green' image
- The very obvious and rapid development of Waitakere has caused serious public and council concern about the loss of green space. Conversely the demand for development land has provided the council with opportunities to negotiate setting aside land for corridor development in return for residential development consent approvals.
- The City Council has strong local support for its greenspace protection policies
- The City Council has a unit with full time staff specifically dedicated to promoting Waitakere's green network
- Much of the land identified for corridor development has limited economic potential and includes salt marshes, gullies, land susceptible to flooding and river slopes. As Waitakere is primarily urban the land also has limited farming potential.

Planners will inevitably confront difficulties in dealing with the practical realities of trying to translate conservation goals into practice. They need to work with those experienced in the amenity and conservation aspects of open space planning not only to identify corridors but also to gain support for corridor developments in general.

Figure 4. Waitakere City Plan



Do corridors work?

The corridor principle does not enjoy universal acceptance amongst conservationists. This is especially the case in New Zealand. Corridors can be seen as one means by which invasive, usually exotic species can colonise indigenous vegetation remnants to the severe detriment of the less robust indigenous species. This concern is especially significant given that, isolation as indicated by the very successful island conservation programmes (Kapiti, Little and Great Barrier islands and its current extension to mainland island programmes such as the Karori Wildlife Sanctuary in Wellington) has often been the saviour of indigenous species and habitats. The primary arguments against corridors can be summarised as follows:

- Many species can disperse across landscapes without corridors
- There is little evidence that the intended species will use the corridors
- Corridors may facilitate the spread of invasive species
- All purpose corridors cannot exist as each species has its own needs
- Management of corridors with their multiple ownerships and uncertain status can be extremely problematic in a way that is not the case in managing reserves

Of the large body of research advocating corridors there is comparatively little which actually evaluates their success in the field in facilitating wildlife movement and dispersal (exceptions include, Collinge, 1998; Dawson, 1994; Overmars et.al's work in Westland; Soule and Gilpin, 1991and recent work in the Amazon by Laurance and Laurance, 1999 and de Lima and Gascon, 1999). In 1994, Dawson undertook research, sponsored by English Nature, (the English equivalent of DoC) to address the question of whether habitat corridors are conduits for plants and animals in a fragmented landscape? The findings were inconclusive. Certainly, it was found many species do not require corridors for dispersal but for species whose dispersal powers are 'middling'. It was concluded that corridors may well permit recolonisation where it would otherwise not occur. With regard to rarer species, Dawson concludes that they are unlikely to benefit from corridors unless it contains within it their specialised and rare habitat. Corridors can only help species which are physically and behaviourally able to use them and these species may well possess adequate dispersal mechanisms anyway. Given that the evidence is not conclusive Dawson summed up as follows:

> The practical conclusion, then, is that habitat corridors should be kept, improved or created to connect other identified nature conservation sites and to lead into inhospitable surroundings where this can be cost-effective. This is partly because the corridors would serve as conduits for some animals and probably plants, and also because we cannot await proof for which these species are… The findings of this review support those who stress that retention, enhancement or provision of corridors should be balanced against alternative measures to conserve biodiversity and that there are situations where scarce resources dictates that the effort goes to these alternatives as priorities (Dawson, 1994, p.67)

Two research programmes which try to address some of the practical questions raised by Dawson and prove that corridors do encourage species movement are Soule and

Gilpin's work (1991) which simulates the relationship between corridor shape and use; and the field research of Collinge (1998). Collinge assessed the effects of habitat isolation and corridors on insect movement and found that corridors reduced the rate of species loss, enhanced recolonisation of medium sized fragments and some species moved preferentially in corridors. In New Zealand Landcare Research in Canterbury is undertaking research into the relationship between habitat size and distribution and species use. Landcare Research's aim is to answer practical questions of vital importance in habitat conservation and restoration, such as how far will a Kereru (native pigeon) fly between habitat patches. As the Kereru is vital in the propagation of some native fruiting trees which are in decline, such information is of critical practical relevance for conservation. This research is still in progress.

In New Zealand conservation is an extremely complex process due to the very sensitive nature of much of the indigenous vegetation, the fragile and endangered status of its fauna and the invasive robustness of exotic habitats, and the scarcity of conservation resources. This means the relative lack of field research on the efficacy of corridors is a major stumbling block in corridor promotion and the evaluation of corridors as a significant conservation tool in New Zealand. Part II now focuses on the application of the corridor concept, and the development of a strategic framework for the restoration of indigenous habitats on the Manawatu Plains.

Part II

The Development of Wildife Corridors in the Manawatu

The problem: Decline of New Zealand's indigenous habitat.

New Zealand has experienced rapid decline in the quantity and ecological health of its indigenous biota since human settlement. The decrease of New Zealand's natural landscape began with Maori who by the 1600s had converted an estimated one third of the natural forests to grassland and through hunting pressures contributed significantly to the extinction of species such as the moa. However, the effects of the Maori on New Zealand's natural areas were compounded and substantially exceeded by the later wave of European settlers from the early 1800s. The rate of environmental despoliation and clearance undertaken by the Europeans remains almost unparalleled by any other country in terms of the pace of change. Within less than one hundred years forest was cleared from a further 23% of the land area (Taylor and Smith, 1997). In addition to forests being cleared, wetlands were drained (85% of New Zealand's wetlands have been lost) and fragile hill country was used as sheep pasture. Lands sacred to Maori were despoiled and river catchments denuded. Not only was the landscape reshaped but so also the flora and fauna was transformed as new species were introduced:

> When people transfer themselves to new land full of what is to them alien life, they immediately seek to re create familiar modes of living. To this end the Polynesians brought to their Aotearoa kumara (sweet potato), taro, yam, gourd dog and rat. Europeans carried in horses, horned cattle, sheep, swine, poultry, household pets, wheat, barley, garden fruits, vegetables and tobacco.

Inadvertently they also brought in animal pests, parasites, diseases and weeds... reflecting a nineteenth century attitude towards nature that may be summed up in the term 'biological dilettantism' the reckless and uninformed diffusion of newly accessible and newly transportable life forms without any rational understanding of consequences (Grey, 1994, p.17).

In New Zealand, the effects of these translocations were catastrophic for most of the indigenous habitats and species. New Zealand now suffers the depredations of approximately 70 million brush tailed possums, (*Trichosurus vulpecula*), deer, rats, stoats, feral cats, and over 200 invasive weeds. About 1000 of the known plant, animal and fungus species are threatened (New Zealand Biodiversity Strategy, 1998). As well as direct animal predation, there is also the competition for food and living resources associated with introduced species. The introduced blackbird competes with the native tui, the hedge sparrow with the fantail (piwakawaka) and the now ubiquitous mallard with the paradise shelduck (putangitangi) and grey duck (parera). Similar competition occurs in the plant kingdom. The problem is further exacerbated by the high degree of endemism of much of New Zealand's biota. For example, all New Zealand's reptiles, 90% of insects and 80% of vascular plant species are endemic. Fortunately, there is cause for some hope amidst all the gloom. New Zealand as a country has one of the highest proportions of its area designated as conservation land, approximately 30% of the total land area. It is a statistic that should be treated with some caution as it masks significant conservation problems.

New Zealand's lowland and coastal habitats

Whilst upland forests are comparatively well protected through both the national park and forest park systems, the situation for other habitats, notably indigenous lowland and coastal forests, is precarious. It is on the coastal plain that the transformation of New Zealand's landscape from indigenous bush to an agro-landscape has been most comprehensive. Park (1995) in his evocative exploration of New Zealand's changing natural heritage, describes the process of transformation on the Plains as follows:

The overall landscape transformation was such that when the Treaty of Waitangi [1840] was signed almost all the plains ecosystems were composed exclusively of plants and animals native to the country now instead, almost every tree, every bird, every living thing on the coastal plains [with a few exceptions] is foreign (Park, 1995, p.331).

The loss of coastal and plains habitat is clearly evident in the following statistics taken from the New Zealand Biodiversity Strategy which assessed the approximate proportion of New Zealand's major environmental domains (i.e. areas of similar climate and geology) remaining as natural habitat. For coastal plains the following percentages were recorded:

Northern central lowland plains	7.7%
North-eastern South Island plains	3.2%
South-eastern South Island plains	1.4%

By way of contrast, upland ranges comprising primarily forest habitats retain substantially more natural habitat. For example:

Northern hard rock ranges	64%
Northern soft rock hill country	33.6%
Nelson Marlborough hill country	77%
West Coast ranges	99.6%

On the coastal plains loss of habitat is especially problematic given that much of the natural habitat that does remain is in poor condition, suffers from pests and predation, often lacks keystone indigenous species, is highly fragmented and may include exotic species. The Manawatu Plains area is part of the North Central Lowland Plains

Fragmentation of natural habitat is a key concern identified in the New Zealand Biodiversity strategy. Particularly important for this study is the New Zealand Draft Biodiversity Strategy's identification of the need for 'restoration activities to restore fragmented, degraded or scarce habitats' (see Figure 5). On the Manawatu Plains, where fragmentation is particularly severe, the priorities for future conservation activities must therefore, focus on protecting more sites and on addressing the related issues of small size as well as the dispersed nature of these sites.

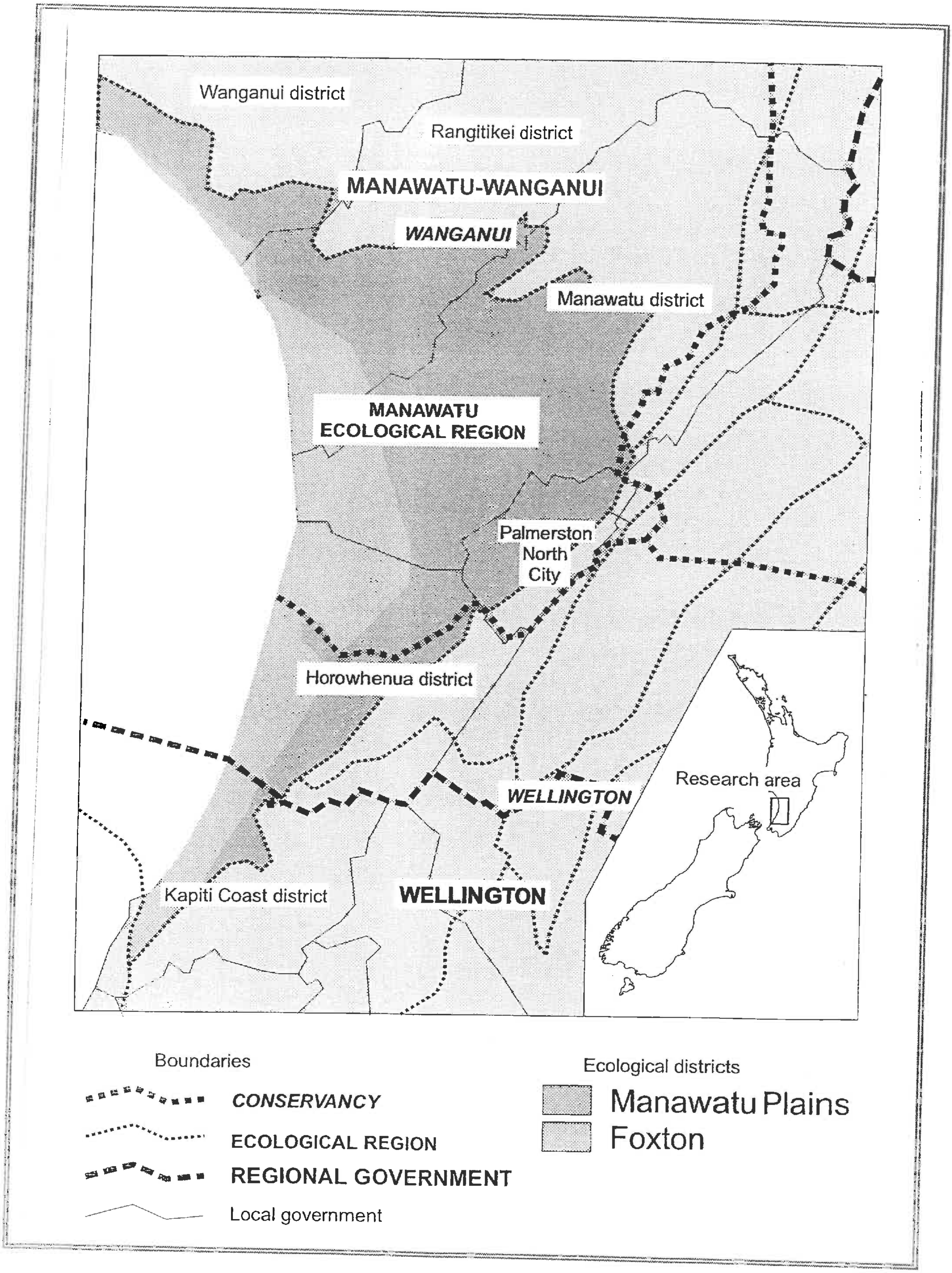
Figure 5. Biodiversity Strategy: Habitat Fragmentation

- Fragmentation of natural areas through ongoing land use changes has left many isolated remnants that are important for biodiversity conservation but vulnerable to continuing degradation, including invasion by pests and weeds and the loss of indigenous species due to reduced populations.
- There is a need for greater recognition and action to restore fragmented, degraded or scarce natural habitat, to halt declining ecological condition and restore essential ecosystem functions, and to extend the area of particular habitat types.
- Restoration initiatives are currently constrained by a lack of knowledge about ecological processes, limited techniques and insufficient incentives and resources for restoration on private land.
- There is a need for greater recognition of the opportunities to restore and reconnect fragmented, degraded or scarce habitats for indigenous species through sympathetic management of production and urban land. (New Zealand Biodiversity Strategy, 1998, p.33)

The Manawatu Plains

Two plains regions in New Zealand that manifest exceptional levels of habitat transformation and whose remaining natural areas are particularly fragile are the Canterbury Plains and the Manawatu Plains. New Zealand has been divided into 268 ecological districts which are grouped into 85 ecological regions. The Manawatu

Figure 6 The Manawatu Ecological Region



Plains is in two ecological districts, the Foxton Ecological District and the Manawatu Plains Ecological District which together form part of the Manawatu Ecological Region. These fall into two conservancies the Wellington Conservancy and the Wanganui Conservancy. The conservancy boundary follows an approximately east west line which bisects the study area, with about 30- 40% falling under the jurisdiction of the Wellington Conservancy. The study area is referred to as the Manawatu Plains although the area studied did not cover all of the plains area. The area included in the study approximates to the area classed as the Manawatu Ecological Region as regards the western boundaries with the sea and the eastern boundaries with the Tararua and Ruahine ranges. The study area in the north extends as far as Koitata on the Turakina River Estuary following the southern river edge to just north of Turakina before heading east to Pohangina. To the south the boundary generally follows the southern banks of the Otaki River but does include a small number of sites along Otaki Gorge Road.

Landscape character

By New Zealand standards the area is intensively settled, comprising intensive agriculture in the lower coastal plains areas. Major towns are Palmerston North, Levin, Fielding, Bulls and there is a developing coastal urban area around Otaki to the south. Habitat loss is a major conservation issue for the area. The Foxton Ecological District Protected Natural Areas Report (PNA report) estimates that at the time of surveying, i.e. 1989-90, less than 5% of the district still had predominantly indigenous vegetation (Ravine, 1992). It described the problem as follows:

> Few ecological districts in New Zealand have been as modified by human activities as Foxton Ecological district. PNA survey of the district was given a high priority by the Department [of Conservation] because of on-going losses and modification of the few natural areas remaining (Ravine, 1992, p.1).

The situation in the highly fertile now intensively farmed Manawatu Plains Ecological District is even worse in conservation terms to that of Foxton.

> Of the 312,300 ha of the district only 5,900 ha, or 1.9% has predominantly indigenous vegetation. This vegetation is found on 750 separate areas, of which most are only a few hectares in extent and few are on flat land. All but a few of these areas have been greatly modified and now have secondary communities often with exotic plants present. (Ravine, 1995, p.21).

The paucity of remaining natural habitat is of even greater concern when levels of protection are examined. Of these 750 areas only 85 have some form of legal protection with these areas making up just 0.51% of the district. The future for indigenous vegetation in the Manawatu Ecological District is bleak, not only is there very little natural vegetation remaining but that which does remain with few exceptions is isolated and highly fragmented. The natural vegetation that does remain covers a diverse range of habitat types. The following represent the key habitat types and associated landforms:

Dunelands

The physiographic character of the Foxton ecological district is based on a dynamic sand dune system which includes dunes laid down under the Koputaroa dune building phase 10,000-20,000 years ago. By contrast the most recent are only 120 years old forming and formed as a result of erosion from coastal dunes following European farming activity (Ravine, 1992). Parabolic dunes are a regular feature in the district. Characteristic of the dunelands are the dune-lakes many of which (Pukepuke Lagoon, Lake Koputara, Lake Papaitonga) are shallow, not fixed and tend to move inland with sand movement in the face of the prevailing winds. Natural dune vegetation is predominantly spinifex, pingao, tauhinu and sand coprosma with sedges, herbs, toetoes, cabbage trees and flax in the wetter dune hollows[1]. Further inland occur, akeake, kanuka, mahoe, ngaio, rewarewa, titoki, and some coprosmas karaka, kohekohe, matai, totara, poataniwha, wharangi, and others. The dunelands suffer problems resulting from the effects of sand stabilisation of mobile dunes as a result of farming and drainage which has had severe effects on the swamps and dune lakes. Degradation also occurs as a consequence of recreational activities such as motorcycling, driving beach buggies and competition between indigenous plants and invasive exotics. These exotics include; jointed rush, lupins, marram, pampas, pines, Spartina anglica, tall fescue, and a range of pasture weeds such as blackberries and gorse.

Swamp forest
Swamp forest once covered much of the district but only a few small remnants now remain. Key species include kahikatea, pukatea, with lesser amounts of rimu and swamp maire. It is likely that the extent of these forests was already much reduced by Maori prior to European settlement.

Estuaries
Associated with the dunelands these include the estuaries of the Otaki, Ohau, Manawatu, Rangitikei and Turakina Rivers. The position of these estuaries changes constantly as they move southwards. The most active movement is associated with the Turakina which moves 100 metres southwards annually. The estuaries are often associated with extensive tidal flats and thus represent important wildlife habitats. The most significant of are those associated with the Manawatu estuary which is nationally important as a feeding and breeding ground for a large number of bird species including international migratory species. Species found at the estuary include for example: the rare black stilt, wrybill, least golden plover, royal spoonbill, terek sandpiper, the Australasian bittern and more commonly; white fronted terns, sharp tailed sandpiper and eastern bar tailed godwit.

Rivers
The plain is traversed by both major and smaller rivers, which are generally slow and meandering near the coast due to their carrying heavy sediment loads. Exceptions include the Otaki River and Te Horo streams both of which are fast moving. Further upstream sediment comprises mainly gravels with the rivers having expansive braided characteristics. Ox bow lakes and associated wetlands occur in the lower reaches of most rivers. The catchments of these rivers are large, the Manawatu being in the extremely unusual position of having headwater catchment areas on both sides of the Tararua and Ruahine mountain ranges. Away from the coast are uplifted marine terraces and cliffs which range in height from 3-45 metres. These cliffs or terraces as

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[1] Most of the species data included in this section is taken from Ravine 1992 and 1995, and DoC 1996 and 1997.

they are commonly referred to, are often well vegetated with indigenous forest, especially in the gullies. In many cases these forest habitats represent the only indigenous habitats in the immediate area. These terraces are critical components of the proposed corridor network.

Sandplain scrub

Generally associated with disturbance either by succession following burning or clearance, or conversely through reclamation by indigenous vegetation of land no longer farmed. Kanuka and manuka dominate and if left further undisturbed it is likely that the scrub habitat would eventually develop into forest. Other species associated with scrub include, cabbage trees, Coprosmas Olearias, tree ferns, and in wetter areas carex secta, flax, sedges, and toetoe.

Lowland forest

On the coastal plain very little forest remains and what there is tends to be in isolated, highly fragmented and often small remnants which only hint at the type and expanse of the original forests that covered the Manawatu Plains. The only large stands of forest remaining in the district are in the Totara Reserve and the Manawatu Gorge, though small remnants of forest at Lake Papaitonga and Round Bush are in good condition. Those forest habitats that have experienced least disturbance comprise mixed podocarps over a tawa dominated mixed broadleaf canopy. The most common species include kahikatea, matai, pukatea, totara, and titoki, whilst rewarewa is increasingly common following disturbance of the forest. The most common smaller species include coprosmas, hangehange, lacebark, kawakawa, kohekohe, mahoe and poataniwha. There can be significant differences in forest habitats and species between forests associated with the plains and those associated with steeper terrace treads and gullies. The quality of the forest remnants has also been reduced by the browsing activities of cattle, deer, and sheep and attacks by pests, notably possums. Introduced plants present particular problems. The species with the greatest impacts are elderberry (found in just about every forest remnant in the eastern half of the district), banana passionfruit, ivy, old mans beard, vines, and wandering jew.

Farmland

Farmland dominates the fertile coastal plain, comprising various types of agricultural cropland and exotic grasslands/pastures. Pastureland is also the dominant habitat on the hill-country used for cattle and sheep grazing. The farmland not only acts as a barrier between remnants but as a source of invasive and pest species e.g., gorse, pampas grass and rabbits. It can also be a source of pollutants, especially fertilisers (air and soil borne) which spread from the farmland into the indigenous remnants

Urban open space

Urban open space comprises a mixture of habitat types ranging from indigenous vegetation remnants to derelict land inhabited by a few hardy exotics. New Zealand's urban areas include large areas of parkland or formal gardens which provide habitats for bird species such as bellbirds and tuis, and for native invertebrates such as wetas and cicadas. The trend towards greater incorporation of indigenous planting in both parks and private gardens means that the importance of these as habitats is increasing and their significance as potential wildlife or green corridors should not be overlooked. The Turitea-Esplanade-Anzac Park area in Palmerston North is a good example of a modified habitat which is increasing in value for indigenous species.

Corridor theory and its application to the Manawatu

In developing the strategic corridor framework for the Manawatu Plains the key aims were as follows

- To support an increase in the proportion of the landscape with natural habitat
- To support and reduce the isolation of natural habitats, and in particular, to try and prevent further isolation of remnant habitats
- To provide conduits for movement of plant and animal species
- To provide a focus for and to support habitat restoration activities.

One decision taken early in the project for pragmatic reasons was to focus on forest rather than wetland or duneland habitats. The reasons being that forest remnants were relatively easy to identify and locate during field research whereas, unless close access to the site is possible, difficulties can be experienced in locating and assessing wetland and dune habitats. Also, the data available on wetland and duneland habitats was often dated as they continue to suffer extensively from drainage and related farming activities. Further, the field work was undertaken whilst the Manawatu Region was suffering exceptionally low rainfall, attributed to the El Nino effect which created further difficulties in wetland identification as many wetlands dried up. Measures were taken nonetheless, to ensure that despite limitations regarding site accessibility key principles for development and key areas with corridor potential were identified. Further research needs to be undertaken to identify corridors specific to these particular habitats. The work on coastal habitats being undertaken by researchers at Massey (Hesp and others) presents an excellent basis on which a strategic corridor framework could be developed.

The project does facilitate the identification of strategic corridors at regional scale, but recognises that further research will be needed to ensure applicability and identification at local or neighbourhood scale and with reference to particular habitat types.

Research methodology

Identifying corridors either existing or potential that would link the ranges with the sea was not possible due to the highly fragmented and modified character of the coastal plain. On the plains there are no substantive examples of remnant corridors. Only in the immediate vicinity of the forest parks were natural corridors of any length observed. Neither were there any substantial examples of self regenerated corridors, though several potential regenerating corridors could be identified.

Following Forman and Godron (in Bennet, 1990) the three main types of corridors identified for the Manawatu were:

- *natural corridors*; a result of natural processes (e.g. streams), vegetation comprises indigenous, exotic and mixed vegetation

- *remnant corridors*; strips of indigenous habitats left after clearance (e.g. vegetated gullies and terraces), in the Manawatu few if any corridors consist of purely indigenous vegetation all evidence some degree of modification
- *regenerated corridors*; regrowth of natural vegetation after clearance usually due to the failure of agriculture and thus are commonly associated with steep land and wetlands, scrub species such as manuka and kanuka are typical of these disturbed areas. In the Manawatu study regenerated corridors are important as these include corridors where regeneration activities could focus to maximise the aims of the project as stated above. Thus these may include both existing and future corridors.

It was envisaged that the prime candidates for corridor development would be the 'natural corridors' in the form of the major rivers, namely the Otaki, Ohau, Manawatu, Rangitikei and Turakina Rivers, all of which provide a direct link between the mountain ranges and the sea. Field surveys showed, that in the upper reaches the rivers tended to be well vegetated, primarily forest. In the lower reaches on the coastal plains the river beds and margins were almost totally devoid of any indigenous vegetation except at their estuaries. Where natural vegetation is evident in the lower river reaches this was predominantly planted willows and associated exotics. The large wide low river beds means that regeneration along and across the rivers can be problematic. On the positive side some of the upper reaches and tributaries of the main rivers, especially the Otaki and Rangitikei rivers were associated with substantial and steep river terraces and gullies. The slopes of these often retained significant indigenous bush remnants and present the most direct possibilities for corridor development. Further, the steep slopes preclude the terraces from easy agricultural development and thus their development as corridors and as the focus for restoration initiatives is less likely to be opposed than similar developments on land viewed as having agricultural or other development potential.

Adjacent to the coast are the dunelands, sand dunes are primarily confined to the immediate vicinity of the coast, and represent the only relatively continuous belt of natural vegetation. Further inland generally following a west-east direction are dune or sand ridges. Whilst most of these now form part of larger pastures and are characteristically covered in exotic grasses some retain some indigenous bush and scrub. Pines have been planted along many in an effort to stabilise the dunes and prevent further erosion. There may be potential therefore, to develop corridors based on extending the existing indigenous habitats and by possibly complementing the pines with indigenous forest which would further contribute to the restoration of lowland forest habitat. Both rivers and dune ridges are important in corridor development. Additional features that were of note are gullies and terraces associated with the rivers.

To identify potential linkages as many sites as possible were visited. Visits were arranged so as to visit sites in order of priority. Sites were visited in the following order, RAPs, DoC sites, Reserves covenants and other protected sites and natural areas identified in the PNA reports which are not protected. The relatively low number of visits for RAPS Foxton was due to the earlier mentioned difficulties of accessing coastal sites, particularly wetlands. Corridors can include sites with both indigenous and exotic vegetation.

Table 1. Sites visited during field research

Site type	Sites identified for survey	Sites visited or seen
RAPS Manawatu Ecological District	24	20
RAPS Foxton Ecological District	27	14
RAPS second tier sites (Foxton Ecological District only)	12	7
Wellington DoC sites	18	16
Manawatu Wanganui DoC sites	51	33
Reserves, covenants and other wildlife areas	24	21
Other natural areas as identified in the Manawatu Ecological District PNA report.	228	104
Total number of sites	**384**	**215**

In addition to the sites enumerated above there were natural habitats or features which though contributing to the natural habitat of the region were not classified as sites and thus not incorporated in the site count. These features are not as well developed in terms of habitat as the main 'sites', however, their function as linkage between sites can be critical. Similarly, his natural linkage may not in itself fulfil all core corridor functions, such as providing a major food source for birds, or acting as a seed bank for regeneration of indigenous trees; nonetheless, it does have an important role to play. For some species for example, it can act as a supplementary food source and as shelter from weather and predators. Corridors thus comprise sites, which perform core habitat functions, and a range of habitat types and features that can provide support for core habitats.

Table 2. Natural habitats and features additional to those classed as sites

Trees	Water features	Scrub*	Others
tree belts hedgerows scattered trees specimen trees	rivers streams drains ponds wetlands damp-grasslands riparian vegetation	scattered scrub gorse overgrown or tall herb areas	parks gardens roadside and railway vegetation formal landscaping

* Scrub comprises low bush and trees which may develop over time into forest.

Data from the field research and from the documented data sources were collated to provide a data record for each site. The following data was thus recorded for each site: basic details such as ecological district, conservation/PNA reference number, local authority, administration/ ownership information, size, access, land use type, habitat type, key species, and presence of any significant natural features. To assist in identifying corridor potential, particular note was taken of presence of any natural features locally, adjoining land use type, presence of potential corridor features such as streams/ gullies/ dune ridges and of any management needs such as the need to control grazing, and the presence of any regeneration either natural or managed. In addition sites were photographed to provide a visual record of the site in the context of its surrounding landscape. A GIS data table using ArcView GIS was constructed which included the following data, site code, location, size, ecological district, whether site was visited during field research, landform e.g. sandplain, gully, beach, habitat and key species (where known). Sites were thus able to be represented visually and data selected for display. For example the GIS could be asked to select for representation all sites with scrub habitat in excess of 6ha in size, or all forest sites situated in gullies. The value of the GIS is that it facilitates representation, manipulation and selection of site data to enable alternative scenarios to be considered.

Whilst it is possible to identify corridors by applying precise size, distance and distribution criteria which could be identified by used of the spatial modelling facilities of ArcView this method was not pursued. Corridors were identified by use of a broader method based on judgement based on visualisation of sites as represented through the GIS and by judgement. Account was taken of factors such as landform and regenerative capacity (e.g. forest remnants on terrace slopes tended to be regenerating better than similar remnants on the sandplain), proximity to corridor features, proximity to nearest similar habitat and other factors which can be difficult to reduce to computer modelling formulae. However, a number of criteria were identified and used to guide the identification process. Thus, within this context of site location, habitat types and structures, potential corridors were identified using the following criteria:

- *number and size of existing natural areas*; priority was being given to core habitat areas provided by protected sites
- *quality and size of natural areas*; larger areas are ecologically more significant as they provide more core habitat and experience fewer edge effects
- *distribution of natural areas*; sites in close proximity to other sites are seen as having higher value. Isolated and island sites despite their 'good' quality habitat have limited potential
- *position within the wider ecological landscape*; priority is given to sites with existing or potential links with natural habitats outside the reserved area
- *proximity to key natural corridor features*; these include features such as rivers, terraces or dune ridges
- *need*; sites which do not meet the above criteria but which can nevertheless, be important if they support corridor development in areas suffering extreme fragmentation.

These six criteria were applied to the Manawatu plains enabling the identification of the following corridors. These indicate corridors whose existing and potential natural habitat is most conducive to corridor development. Corridors are discussed in order of geographical location from Otaki on the southern edge of the Plains to the Rangitikei River in the north.

Proposed Corridors

Otaki River

The shortest possible link between the ranges (Tararua Forest Park) and the sea. Initially, the field research was to be confined to the area between the Otaki River and the Turakina River. This explains why the topographic base map does not cover the southern side of the Otaki. It was an omission that only became clear during field research when the potential of the Otaki corridor and the contribution of sites on both sides of the Otaki River became evident.

Table 3. Otaki River Corridor

Site identity (key sites only)	*Ecological District/ Conservancy*	*Size (ha)*	*Habitat*
Otaki River : main corridor			
R25001	DoC Wellington	28	Dune - wetland
25A	Manawatu E.D*.	1	Terrace - forest
S25026	DoC Wellington	3	Gully - forest
RAP 5	Manawatu E.D.	14	Terrace - forest
18	Manawatu E.D.	1	Terrace - gully forest
22A	Manawatu E.D.	1	Terrace - treeland
RAP 2	Manawatu E.D.	15	Terrace - gully forest
Otaki River North: link corridor			
RAP 8	Manawatu E.D.	7	Terrace - forest
RAP 7	Manawatu E.D.	4	Gully - forest
RAP 6	Manawatu E.D.	10	Terrace - gully - forest
RAP 3	Manawatu E.D.	2	Floodplain - forest
32	Manawatu E.D.	4	Terrace - gully - forest
32A	Manawatu E.D.	3	Terrace forest/scrub
Otaki River South: link corridor			
23A	Manawatu E.D.	2	Terrace - forest
23C	Manawatu E.D.	2	Terrace - forest - treeland
RAP 4	Manawatu E.D.	4	Terrace - forest
31	Manawatu E.D.	1	Terrace - forest
20A	Manawatu E.D.	2	Terrace - shrubland
23B	Manawatu E.D.	1	Terrace - forest
Corridor notes: Good semi-continuous vegetation on northern terrace slopes, scattered totara pasture and several bush remnants on southern side. Minimal indigenous vegetation between the power lines and estuary.			

* Ecological District

Ohau River

A corridor that comprises areas that are well vegetated in the upper reaches but lacking in natural vegetation towards the coast. The river is supported by good coastal vegetation between the Ohau River estuary and Waikawa Stream estuary to the south. The prime area of existing and future potential development is through the development of a possible branch corridor linking the ecologically significant Lake Papaitonga site with already regenerating areas surrounding Lake Horowhenua. A link corridor could be developed along the Hokio stream which is close to river terraces with regenerating scrub habitat and also along Hokio Sand road close to which are dune ridges also with developing scrub habitats. Several regeneration projects are being undertaken here, on the shores of Lake Horowhenua, at the Arawhata Conservation Covenant, at site 83B, and around Lake Papaitonga. These schemes especially that at Lake Horowhenua suggest good support for locally based regeneration initiatives.

Table 4. Ohau River Corridor

Site identity (key sites only)	***Ecological District/ Conservancy***	***Size (ha)***	***Habitat***
Ohau River: main corridor			
S25011	DoC Wellington	1	Riverbank
RAP 13	Manawatu E.D.	1	Floodplain - treeland
67	Manawatu E.D.	1	Terrace - forest
66A	Manawatu E.D.	1	Terrace - forest
60B	Manawatu E.D.	1	Floodplain - treeland
62A	Manawatu E.D.	1	Floodplain - treeland
64	Manawatu E.D.	3	Terrace - forest
67C	Manawatu E.D.	1	Terrace - forest
67B	Manawatu E.D.	1	Terrace - forest
68	Manawatu E.D.	4	Terrace - treeland
Ohau estuary to Waikawa estuary : link corridor			
RAP (2) 5	Foxton E.D.	100	Estuary- saltmarsh
S25003	DoC Wellington	15	Beach - duneland
RAP 13	Foxton E.D.	20	Saltmarsh
S25002	DoC wellington	5	Beach - duneland
Lake Papaitonga Horowhenua/ Hokio Stream and Levin Sewage Plant: link corridors			
70	Manawatu E.D.	3	Floodplain - wetland
70A	Manawatu E.D.	1	Floodplain - treeland
S25024	DoC Wellington	2	Riverbank
RAP (2) 6	Foxton E.D.	1	Duneland - forest
S25006	DoC Wellington	120	Dunelake - forest
RAP (2) 8	Foxton E.D.	10	Duneland - scrub
RAP (2) 7	Foxton E.D.	4	Duneland - forest
S25025	DoC Wellington	4	Floodplain - forest
83B	Manawatu E.D.	1	Floodplain - forest
RAP 15	DoC Wellington	50	Sandplain - duneland forest-

			shrubland - wetland
RAP 14	DoC Wellington	2	Sandplain – swamp - forest
Corridor notes: Corridor centres on the Ohau River with some good forest remnants and regenerating forest, patches comprising numbers of totara trees in upper reaches, very little natural vegetation in lower reaches, but good duneland sites along the coast. A focus for regeneration could be to link Lake Papaitonga and Lake Horowhenua and to develop linkages along Hokio Stream and Hokio Sand road alongside which are dune ridges with developing scrub habitat.			

Manawatu River

The most difficult of the corridors to realise in that there is very little natural vegetation along the corridor. The Manawatu River does, however, present the only real corridor opportunity for this part of the Manawatu Plains. Existing vegetation along the corridor is primarily exotic willow plantings and exotic grassland. Only towards the estuary does natural vegetation in the form of saltmarsh, wetland and duneland habitats emerge, with particularly good dune habitat along the Foxtangi dunes. Upstream are remnants of the extensive flax swamps that once covered much of the area. These could regenerate to form significant wetland habitats. In the longer term, further links will need to be developed along the Manawatu River between Opiki and the Turitea. At present this part of the river is primarily exotic grassland with some trees and riverine scrub, mostly willows. A link with the Himitangi Scientific reserve area is recommended (see table 9 on core habitats). Two potential links to the ranges have been identified along the Mangaore stream and the Tokomaru River. Except for the upper reaches of the Tokomaru at Horseshoe Bend, however, neither has any indigenous vegetation of note.

Table 5 Manawatu River Corridor

Site identity (key sites only)	***Ecological District/ Conservancy***	***Size (ha)***	***Habitat***
Manawatu River: main corridor			
70067	DoC Manawatu Wanganui	25	Estuary - mudflats
RAP 22	Foxton E.D.	200	Estuary - saltmarsh
S24502	DoC Wellington	1	Riverbank
S24501	DoC Wellington	19	Duneland - shrub
RAP (2) 10	Foxton E.D.	2	Duneland - floodplain - forest
70066	DoC Manawatu-Wanganui	192	Floodplain - swamp - flax
126A	Manawatu E.D.	2	Floodplain - forest
124A	Manawatu E.D.	1	Floodplain - forest
132	Manawatu E.D.	2	Floodplain - forest
136	Manawatu E.D.	6	Gully - wetland - treeland
140A	Manawatu E.D.	1	Floodplain - treeland - forest
152	Manawatu E.D.	2	Floodplain - forest
Opiki Stewardship	Manawatu E.D.	5	Floodplain - forest
141B	Manawatu E.D.	2	Floodplain - wetland - treeland

151B	Manawatu E.D.	3	Floodplain - treeland
70060	DoC Manawatu Wanganui	26	Floodplain - pasture
151A	Manawatu E.D.	1	Floodplain - willows
70610	DoC Manawatu Wanganui	6	Floodplain - grassland
150, 150A and Akers road bush	Manawatu E.D.	3	Floodplain - treeland
Mangaore – Tokomaru: link corridors			
S24505	DoC Wellington	1	Floodplain - grassland
70608	Manawatu E.D.	9	Riverbank - pasture
70061	Manawatu E.D.	45	Floodplain - swamp - flax
Horseshoe Bend	Manawatu E.D.	5	Rivervalley - forest
Corridor with very little natural vegetation but represents the main linkage between the coast and the ranges across the plains.			

Kahuterawa- Manawatu rivers

A relatively short corridor whose development is realisable in the near future. A number of regeneration projects focused around the Kahuterawa River and Keebles Bush are already underway. Serious consideration is also being given to a green corridors project focusing on the Turitea River and Massey University campus. Further developments linking the indigenous forest remnants at the Esplanade and Anzac Park through the Manawatu River could create a substantial multi-functional corridor with both ecological and recreational benefits.

Table 6 Kahuterawa – Manawatu River (included in Map 4)

Site identity (key sites only)	***Ecological District/ Conservancy***	***Size in ha***	***Habitat***
Kahuterawa – Manawatu Rivers: main corridor			
139A	Manawatu E.D.	1	Terrace - forest
70677 (no longer included in CMS)	DoC Manawatu Wanganui		Floodplain- scrub
153	Manawatu E.D.	2	Floodplain – forest
158	Manawatu E.D.	2	Floodplain – forest
162A	Manawatu E.D.	1	Floodplain – forest
77012	Manawatu E.D.	15	Terrace – forest
Bledisloe Park	Manawatu E.D.	5	Terrace – forest
Esplanade	Manawatu E.D.	7	Floodplain – forest
Anzac Park	Manawatu E.D.	3	Terrace – gully - forest
Good regenerating forest at Keebles Bush, Bledisloe Park and along the Kahuterawa River. The corridor has significant natural remnants with mixed natural vegetation along the rivers which could be supplemented to form a continuous corridor.			

Rangitikei River

Ideally the Rangitikei would form a major corridor but the main river suffers for the most part from a lack of natural vegetation except for exotics such as willows. Adjoining and local streams such as the Rangitawa, and Mangaone West retain greater amounts of indigenous forest (in places reasonably substantial as at RAP 18).

Further potential is offered by associated natural features such as the ridges along Pryce's line and the gullies towards Tokorangi road and along the Porewa Stream. The corridor is characterised by a relatively high number of small, extremely fragmented forest remnants. Individually these have limited ecological value but through regeneration could form an effective and substantial corridor in this otherwise intensively farmed area.

Table 7 Rangitikei River

Site identity (key sites only)	*Ecological District/ Conservancy*	*Size (ha)*	*Habitat*
Rangitikei River: main corridor			
195D	Manawatu E.D.	15	Floodplain- treeland
187A	Manawatu E.D.	1	Gully - terrace - forest - scrub
187B	Manawatu E.D.	2	Terrace – forest - treeland
188C	Manawatu E.D.	3	Gully - terrace - forest
188D	Manawatu E.D.	9	Gully - terrace - forest - treeland
RAP 21	Manawatu E.D.		
211A	Manawatu E.D.	15	Rivervalley - forest
224C	Manawatu E.D.	2	Terrace - treeland
219B	Manawatu E.D.	14	Terrace - treeland
219A	Manawatu E.D.	1	Terrace - scrub
219C	Manawatu E.D.	20	Floodplain - terrace - treeland
224B	Manawatu E.D.	5	Terrace - treeland
222B	Manawatu E.D.	10	Terrace - floodplain -treeland
Ngaio- Mingaroa roads: link corridor			
185E	Manawatu E.D.	1	Gully - treeland
185F	Manawatu E.D.	1	Terrace - forest
185G	Manawatu E.D.	1	Gully - terrace - forest
187D	Manawatu E.D.	1	Terrace - scrub
187C	Manawatu E.D.	2	Gully - forest
Scattered bush and trees along Ngaio road stream, and the terrace east of Mingaroa Road and continuing towards 187D and 187C following the gully.			
Pryce Line: link corridor			
188G	Manawatu E.D.	3	Terrace - treeland
188F	Manawatu E.D.	3	Terrace - forest
188E	Manawatu E.D.	3	Terrace - treeland
212D	Manawatu E.D.	3	Terrace - forest
Large area of scrub at Kakariki extending along Rangitawa Stream, ridge with good tree cover along Pryce's line towards 212D, several other bush patches close by towards Tokorangi road which could form part of the corridor.			
Mangaone West Stream			
70071	DoC Manawatu Wanganui	7	Floodplain - forest
70030	DoC Manawatu Wanganui	1	Riverbank - grassland
70072	DoC Manawatu Wanganui	1	Floodplain - forest
181	Manawatu E.D.	7	Floodplain - treeland - forest

181C	Manawatu E.D.	1	Sideslope - forest
178K	Manawatu E.D.	3	Riverbank- terrace - forest
178J	Manawatu E.D.	1	Terrace - treeland
178D	Manawatu E.D.	1	Terrace - forest
RAP 18	Manawatu E.D.	20	Terrace - floodplain - forest
Lees rd replanting scheme	Manawatu E.D.		Roadside tree planting scheme
Te Rakehou and Managhs Rd scrub	Manawatu E.D.		Scrappy bush, scrub around some remnants
178G	Manawatu E.D.	4	Floodplain - terrace - forest
178H	Manawatu E.D.	1	Terrace - forest
192I	Manawatu E.D.	1	Gully - forest
192H	Manawatu E.D.	1	Sideslope - forest
192G	Manawatu E.D.	1	Sideslope - treeland
Rangitawa Stream	Manawatu E.D.		
Corridor could be continued through Halcome to link with Rangitawa stream and thus by Ngaio- Mingaroa roads link to the Rangitikei River Corridor			

Pohangina Valley

The corridor links the two major sites of the Manawatu Gorge, the largest area that directly adjoins the plains which is still substantially naturally vegetated and the Totara Reserve. The Totara Reserve is at the northern end of the Pohangina River and together with a few smaller reserves represents approximately 300ha of predominantly forested land, and is considered to be the finest forest in the ecological district. The corridor follows the Pohangina river which includes sites and regenerating indigenous vegetation along the steep river terraces, notably at Ashurst Domain, Raumai and Awahou South. Potential branch corridors could be developed along Beehive Creek to the north west, the Makohine Stream to the east and to a lesser extent the along the terraces and gullies to the north of Valley road.

Table 8. Pohangina Valley

Site identity (key sites only)	***Ecological District/ Conservancy***	***Size (ha)***	***Habitat***
Pohangina Valley: main corridor			
70027	DoC Manawatu Wanganui	596	Gorge - forest
Ashurst Domain	Manawatu E.D.	4	Floodplain - terrace- forest
RAP 17	Manawatu E.D.	8	Floodplain - treeland- swamp
177C	Manawatu E.D.	8	Terrace - treeland- grassland
173F	Manawatu E.D.	2	Gully - scrub
180O	Manawatu E.D.	4	Floodplain - forest
180P	Manawatu E.D.	1	Floodplain - forest
180R	Manawatu E.D.	4	Gully- forest - scrub
180S	Manawatu E.D.	10	Gully - forest - scrub

180N	Manawatu E.D.	1	Terrace - forest
180U	Manawatu E.D.	11	Terrace - forest- scrub
180M	Manawatu E.D.	6	Terrace – gully - forest - scrub
190L	Manawatu E.D.	10	Terrace – gully - treeland
190M	Manawatu E.D.	6	Terrace – gully - forest
70225	DoC Manawatu Wanganui	21	Floodplain - grassland
70223	DoC Manawatu Wanganui	20	Floodplain - grassland
190P	Manawatu E.D.	2	Floodplain - treeland
190Q	Manawatu E.D.	2	Terrace – gully - scrub
190T	Manawatu E.D.	10	Gully - forest - scrub
70221	DoC Manawatu Wanganui	3	Floodplain - forest
RAP 20	Manawatu E.D.	2	Terrace – gully - forest
190W	Manawatu E.D.	6	Gully – forest - scrub
Totara Reserve and Pohangina Domain	Manawatu E.D.	300	Floodplain – terrace - forest
Good vegetation along terraces, mainly on the eastern side with good potential links to the Ruahine forest park. Two excellent core habitats at either end of the corridor the Manawatu Gorge and the Totara Reserve. The river valley itself comprises mainly exotic grasslands and trees. The development potential lies with the terraces and forest reserves not the river itself.			

Core Habitat Areas

In identifying corridors for development it became clear that there were habitats that possessed good regeneration potential but which did not fall within any of the proposed corridors. These included:

- Areas with one or more sites comprising good quality habitat, with other natural vegetation such as scrub or treeland close by: their location means that they would not contribute to the corridors identified above but could benefit from being given additional protection or be developed through targeted regeneration activities to form core habitat areas
- A number of remnants close together which offer easy potential for development as a larger habitat unit via micro-corridors: these are areas where though the value of the individual habitat patches is low, the cumulative potential that they offer is significantly higher given the substantial reduction in edge habitat and increase in core habitat
- Habitats which are particularly important given the severe deficit of natural vegetation in the area making their protection and restoration particularly important.

A number of areas with potential for development as core habitats were thus identified.

Table 9. Areas with potential for development as core habitats

Site identity (key sites only)	*Ecological District/ Conservancy*	*Size (ha)*	*Habitat type*
Himitangi Scientific Bush Reserve			
70062	DoC Manawatu Wanganui	19	Duneland - forest
RAP (2) 11	Foxton E.D.	10	Sandplain - treeland
Barkers Bush Scenic Reserve	Foxton E.D.	7	Duneland - forest
Also treeland and scrub and wet grassland outside the above reserves which could link with existing protected areas			
Rangitikei Estuary			
RAP 2(14)	Foxton E.D.	50	Estuary - saltmarsh
70045	DoC Manawatu Wanganui	2	Sandplain - pasture
70046	DoC Manawatu Wanganui	7	Floodplain – wetland - pasture
70023	DoC Manawatu Wanganui	4	Floodplain - pasture
70024	DoC Manawatu Wanganui	3	Floodplain pasture
70715	DoC Manawatu Wanganui	1	Riverbed
70047	DoC Manawatu Wanganui	10	Estuary - dunes
RAP 26	Foxton E.D.	5	Sandplain - rushland
RAP 27	Foxton E.D.	159	Dunes
70044	DoC Manawatu Wanganui	80	Dunelake
Gortons Bush			
RAP 22	Manawatu E.D.	200	Terrace - forest
216A	Manawatu E.D.	2	Terrace - forest
216B	Manawatu E.D.	3	Gully - scrub
216C	Manawatu E.D.	1	Terrace - forest
205C	Manawatu E.D.	1	Sideslope - forest
Cheltenham Cross rd and Makino rd	Manawatu E.D.		Treeland - bush remnants
Koitata dune wetlands			
RAP 36	Foxton E.D.	8	Duneland
RAP 35	Foxton E.D.	70	Duneland - tidalflats
70032	DoC Manawatu Wanganui	63	Dunes
RAP 37	Foxton E.D.	100	Sandplain - duneland - swamp
Kitchener Park Bush			
70030	DoC Manawatu Wanganui	1	Riverbank - grassland
70072	DoC Manawatu Wanganui	1	Floodplain - forest
70071	DoC Manawatu Wanganui	7	Floodplain - forest
181	Manawatu E.D.	7	Floodplain - treeland - forest
Kitchener Park			Floodplain - parkland -forest - regenerating bush
Lethbridge Road bush			
188I	Manawatu E.D.	1	Sideslope- forest

183F	Manawatu E.D.	1	Terrace - forest
183G	Manawatu E.D.	2	Gully - forest - scrub
183H	Manawatu E.D.	3	Terrace - forest - scrub
183E	Manawatu E.D.	1	Terrace - forest
183J	Manawatu E.D.	3	Gully - forest
Forest Lakes Road			
RAP 10	Foxton E.D.	15	Sandplain - treeland - forest
RAP 11	Manawatu E.D.	20	Sandplain - dunelake
45	Manawatu E.D.	3	Sideslope - forest
RAP (2) 3	Foxton E.D.	6	Dunelake
RAP 9	Manawatu E.D.	15	Gully - forest - wetland
42A	Manawatu E.D.	3	Terrace - gully - forest - treeland
Lakes Papaitonga and Horowhenua			
S25006	DoC Wellington	121	Sandplain - dunelake - forest
RAP (2) 7	Foxton E.D.	4	Duneland - forest
RAP 14	Foxton E.D.	20	Duneland -saltmarsh
RAP 15	Foxton E.D.	50	Sandplain - duneland - forest - shrubland
S25025	Manawatu E.D.	4	Floodplain - forest
83B	Manawatu E.D.	1	Floodplain - forest
Turakina - Bulls Dunelakes			
RAP 34	Foxton E.D.	15	Dunelake
RAP 32	Foxton E.D.	15	Dunelake
70604	DoC Manawatu Wanganui	2	Dunelake - pasture
RAP 30	Foxton E.D.	15	Dunelake
RAP 31	Foxton E.D.	25	Dunelake
Lake Heaton	Foxton E.D.		Dunelake
Lake Hickson	Foxton E.D.		Dunelake
Lake Bernard	Foxton E.D.		Dunelake
Lake Dudding	Foxton E.D.		Dunelake

Future developments

The proposed corridors and core habitats are indicative rather than definitive. Development and implementation of the proposed corridors is highly unlikely in the short term, given the variations in tenure, the institutional arrangements and other difficulties associated with corridor development. Development of these corridors will not be easy and a range of problems will need to be addressed. These include problems general to the development of wildlife corridors in New Zealand, and problems specific to the development of corridors in the Manawatu area (see Table 5). The problems and difficulties must, however, be balanced against potential ecological benefits and the need to maintain the productive capacity of the Plains. The long term prognosis even for sites that have some protection such as Recommended Area for Protection or sites managed by the Department of Conservation, often poor and for those that lack protection prospects are worse. The isolation of these fragments, many

Table 10. Problems and benefits envisaged in developing corridors

Benefits to the Manawatu	Problems Specific to the Manawatu	Specific to New Zealand
• Restores and increases number of areas with natural habitat • Addresses fragmentation, reduces edge effects for existing natural habitats • Facilitates spread of wildlife and flora by linking reserves especially linkages with forest parks • Redresses process of degeneration of existing habitats, especially of reserves • Improves quality of natural resources overall, especially water quality, stabilises soils and reduces erosion • Promotes recolonisation of reserves and isolated habitat patches • Encourages support for natural habitats within the community, encourages greater understanding of corridors • Encourages landscaping schemes which focus on the use of native species • Supports ecosystem functioning at regional and local scales • Promotes and supports natural habitats on unreserved land	• Highly fragmented habitats on coastal plain, no existing corridors of any substance, and small number of protected areas • Current and past landscaping programmes (especially those used by regional council for rivers) focus on use of exotics primarily willows, is limited understanding of regeneration techniques locally • Most natural habitat is on private land and unprotected. No means of requiring or funding private landowners to support corridor development. Anticipated resistance by private landowners to corridor development. Landowners would require compensation for loss of productive land • Most corridors will cover land in multiple land ownership • Use of land by stock which inhibits regeneration of existing and potential future natural habitat • Limited understanding on the part of landowners, land managers, planners and others of corridors • No strategic biodiversity plan for all natural habitats in the area • Lack of examples of corridor development that could be used as a guide • Concern that corridors would facilitate the colonisation of remnant habitats by pest species	• No legislative or policy support for corridors • Minimal resources available, these directed to reserves, and endangered species, none for regeneration or corridor programmes • Opposition from private landowners to protection of ecologically significant landscapes, strong opposition to perceived loss of production land associated with ecological developments • Limited expertise and application of corridor theory in New Zealand • Perceived need to focus on critical ecological issues and areas e.g. rare species conservation, offshore island conservation programmes • Focus on high quality indigenous habitats in ecological programmes • Lack of field research, data and published research on corridors in New Zealand • Lack of ecological and biodiversity data at scale necessary to develop corridors • Lack of resources • Concern that corridors would facilitate the colonisation of remnant habitats by pest species

of which are only one or two hectares in area, means they are often extremely fragile. They are vulnerable to edge effects and frequently suffer by being at a remove from the seed and wildlife sources necessary for reproduction and maintenance. Even larger habitat remnants, such as Lakes Papaitonga and Horowhenua, are showing ecological stress as indicated, for example, by worryingly low lake levels (probably due increasing groundwater abstraction in the adjacent farmland) in Lake Papaitonga in 1998.

The New Zealand Draft Biodiversity Strategy highlights fragmentation and associated impacts on rare and threatened ecosystems, as representing a major conservation issue for New Zealand. The Manawatu Plains and its component ecosystems represent one of the worst affected landscapes in New Zealand. Whilst useful initiatives are being undertaken in the field of habitat conservation and restoration on the Plains such as the restoration programmes at Lake Horowhenua, there is no overall strategy which looks at habitats and ecosystems at a strategic level. The conservation focus for the Department of Conservation is on land that it administers. There is no comprehensive long term strategy for either the remaining private land or for interactions between habitats on Department of Conservation and private land. Resources, especially financial incentives for conservation on private land, are too limited to offer any real conservation encouragement for landowners. The Manawatu Plains comprises two Department of Conservation conservancies, two regional councils and five district councils for whom there is no legislative requirement to work together at the strategic level for conservation.

The findings from the Manawatu study have resonance for areas outside New Zealand where similar processes of fragmentation of natural habitats, resulting from the development of land for production and human development occur. Corridors can act as an important tool in addressing fragmentation through providing linkages and increasing the proportion of the landscape under natural habitat. Corridors alone though, as the Manawatu study shows are insufficient. There needs to be recognition that many significant natural remnants due to their physical location, will not form part of any proposed corridor. They will nonetheless, still need to form part of a wider conservation strategy if they are not to continue to suffer the effects of fragmentation and isolation. Similarly any conservation strategy will need to address the relationship between the reserved and non reserved landscape. In the Manawatu the reserved portion alone is too small to support and sustain the habitats and species associated with the Plains area. At the organisational level the need for collaborative efforts across the different institutions, organisations and land owners for conservation at strategic level is imperative if the conservation and restoration of natural areas is to be achieved.

For the Manawatu Plains, the practical implications of instituting a network of corridors and core habitats are not to be underestimated. At no stage was it envisaged that the proposed network would be implementable in the near future. What was sought was the presentation of proposals that will initiate discussion and thinking on the development of ecological corridors at the strategic level and the role planning can play in developing such corridors. Hopefully this study will be a catalyst in furthering discussion, and focus attention on the restoration and rehabilitation of indigenous habitats on the Manawatu Plains which represent a unique but undervalued part of New Zealand's natural heritage

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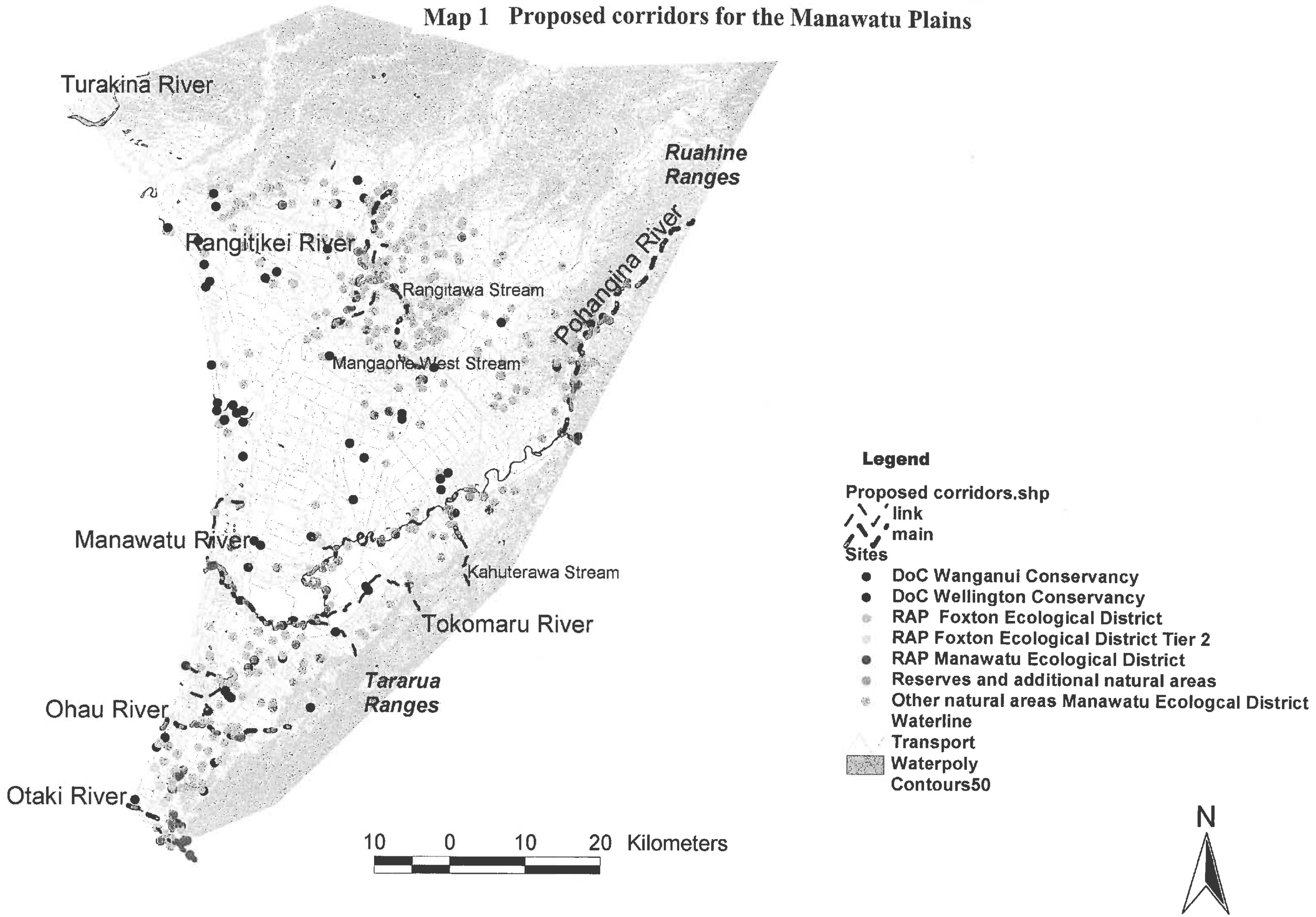
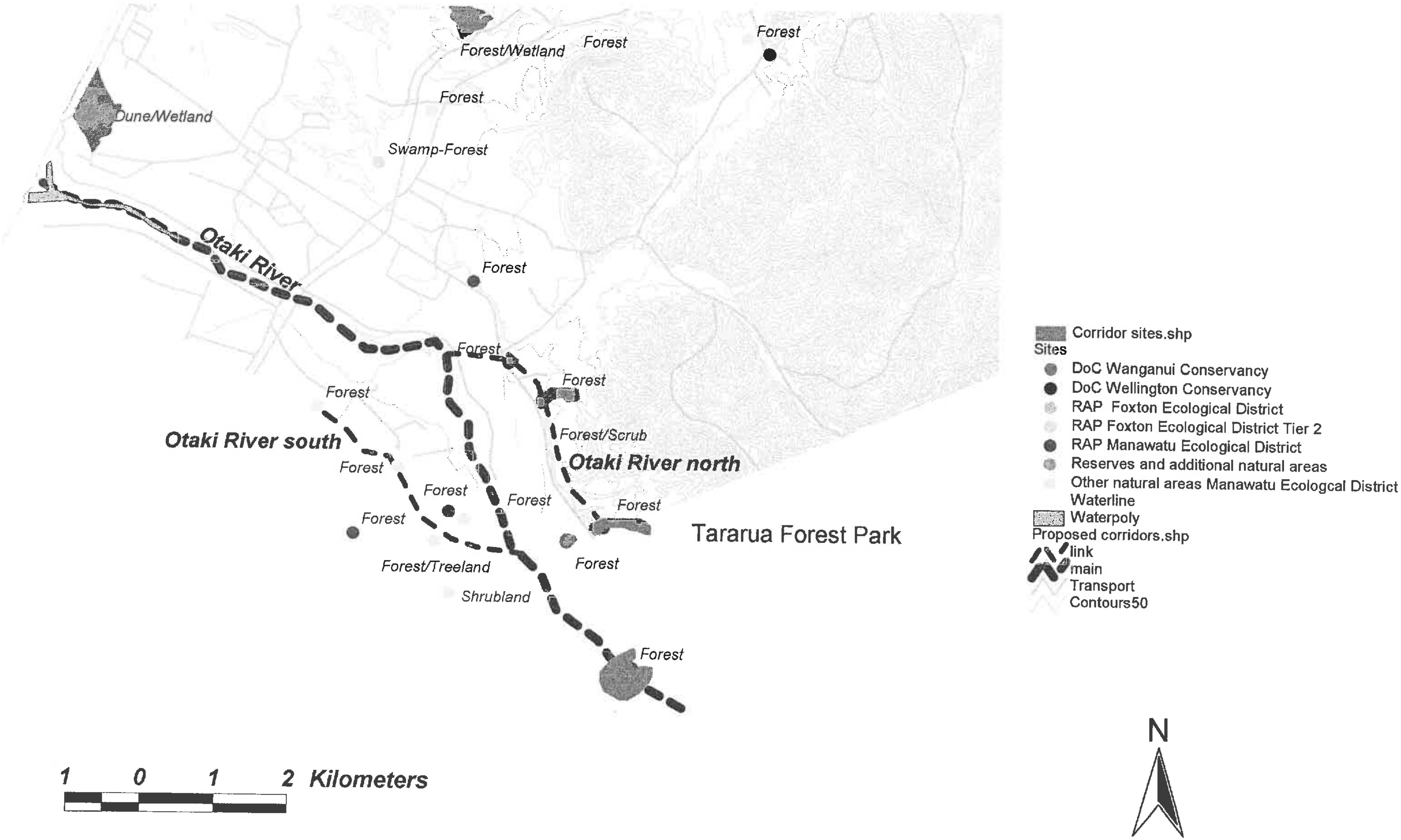
Part III Corridor and Core Habitat Maps for the Manawatu

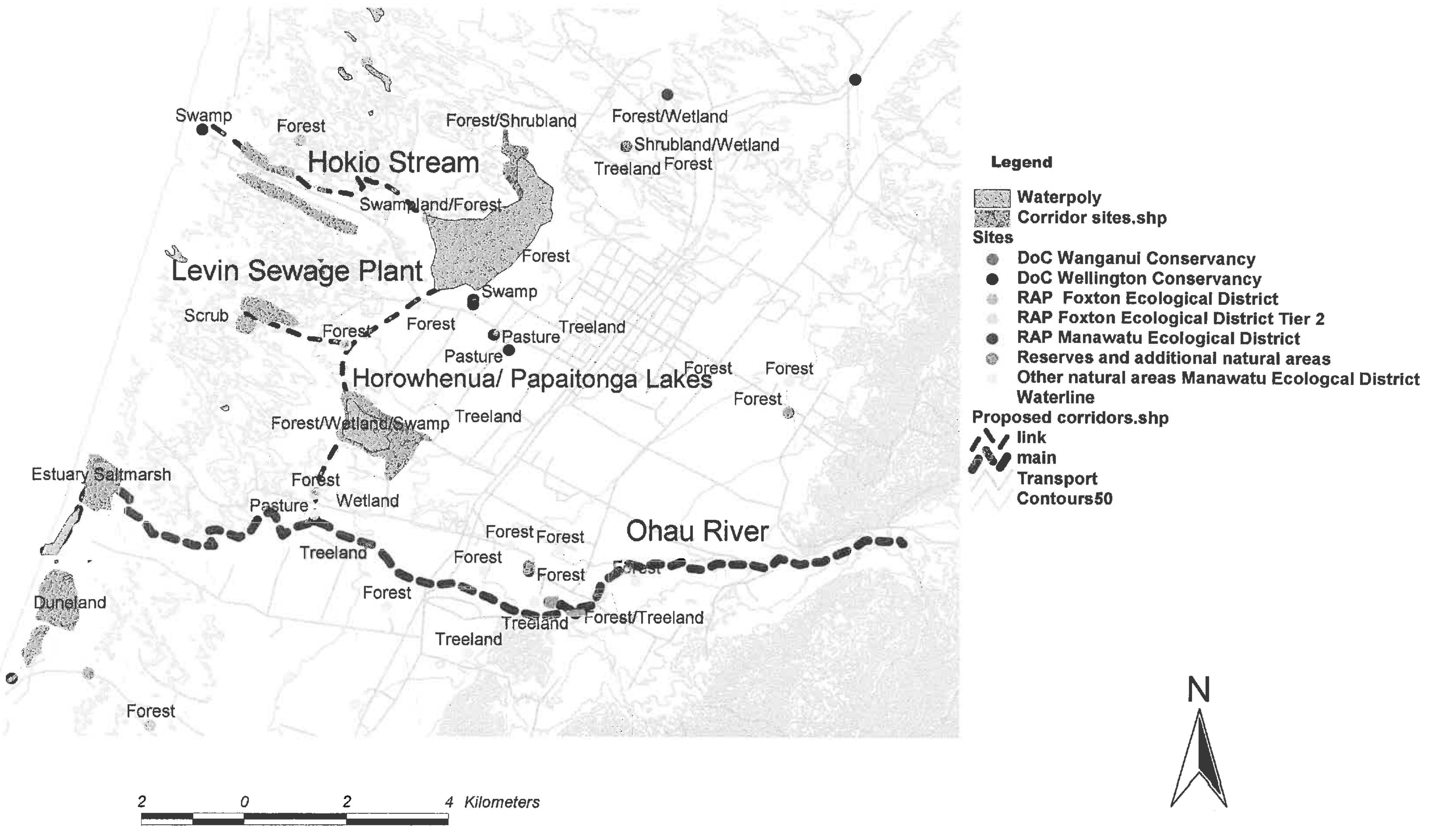
Map 1 Proposed corridors for the Manawatu Plains



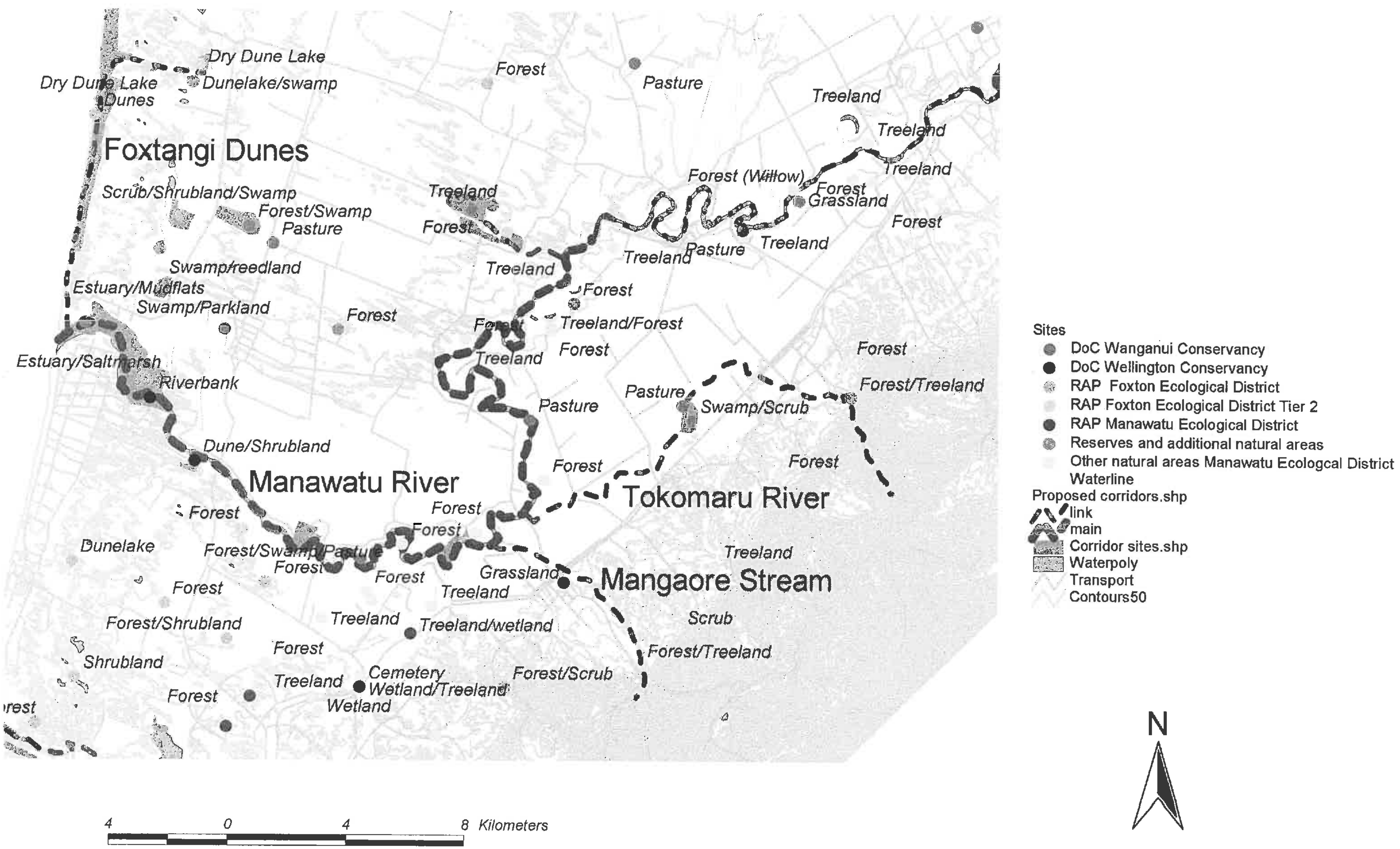
Map 2 Otaki River Corridor



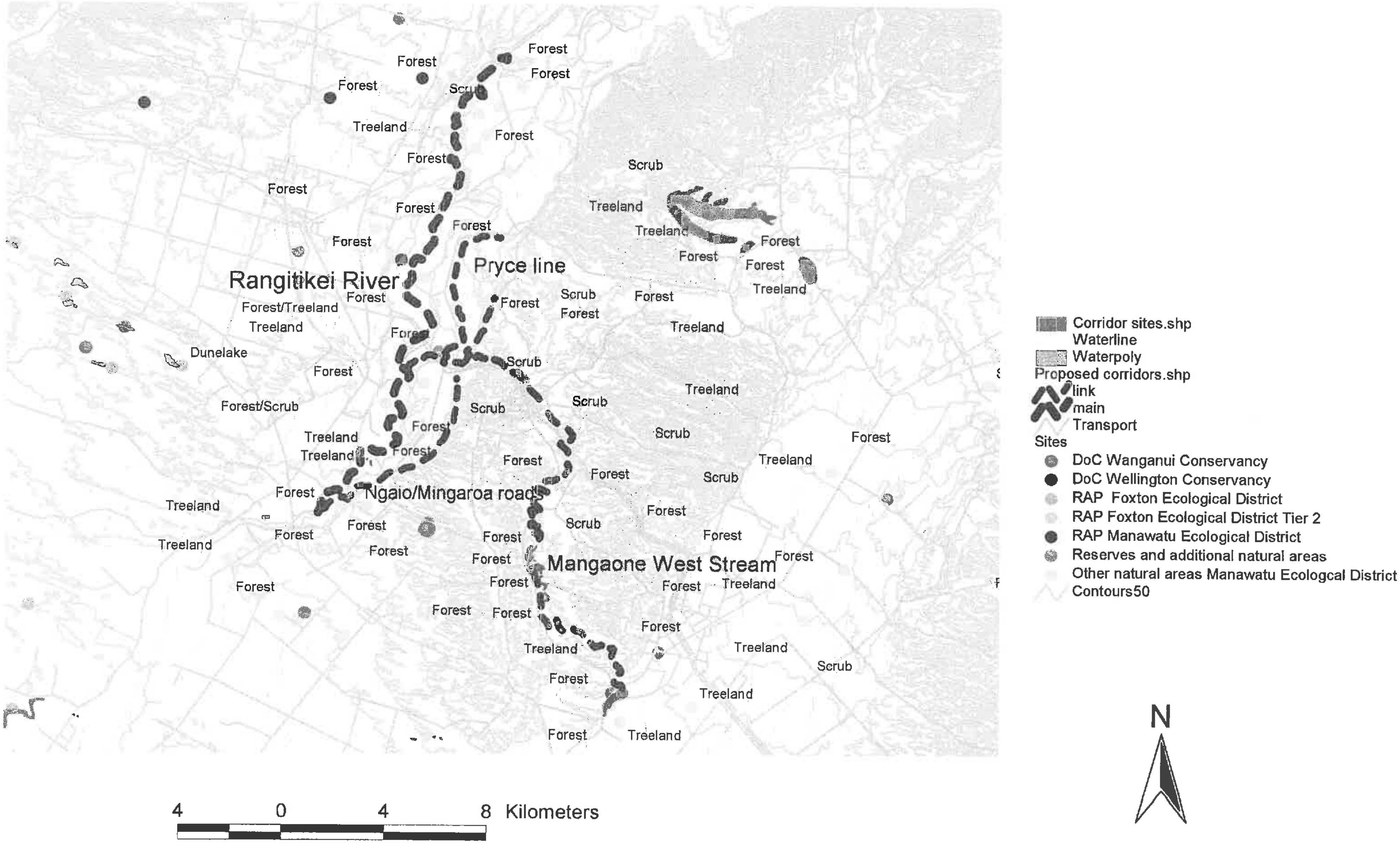
Map 3 Ohau River Corridor



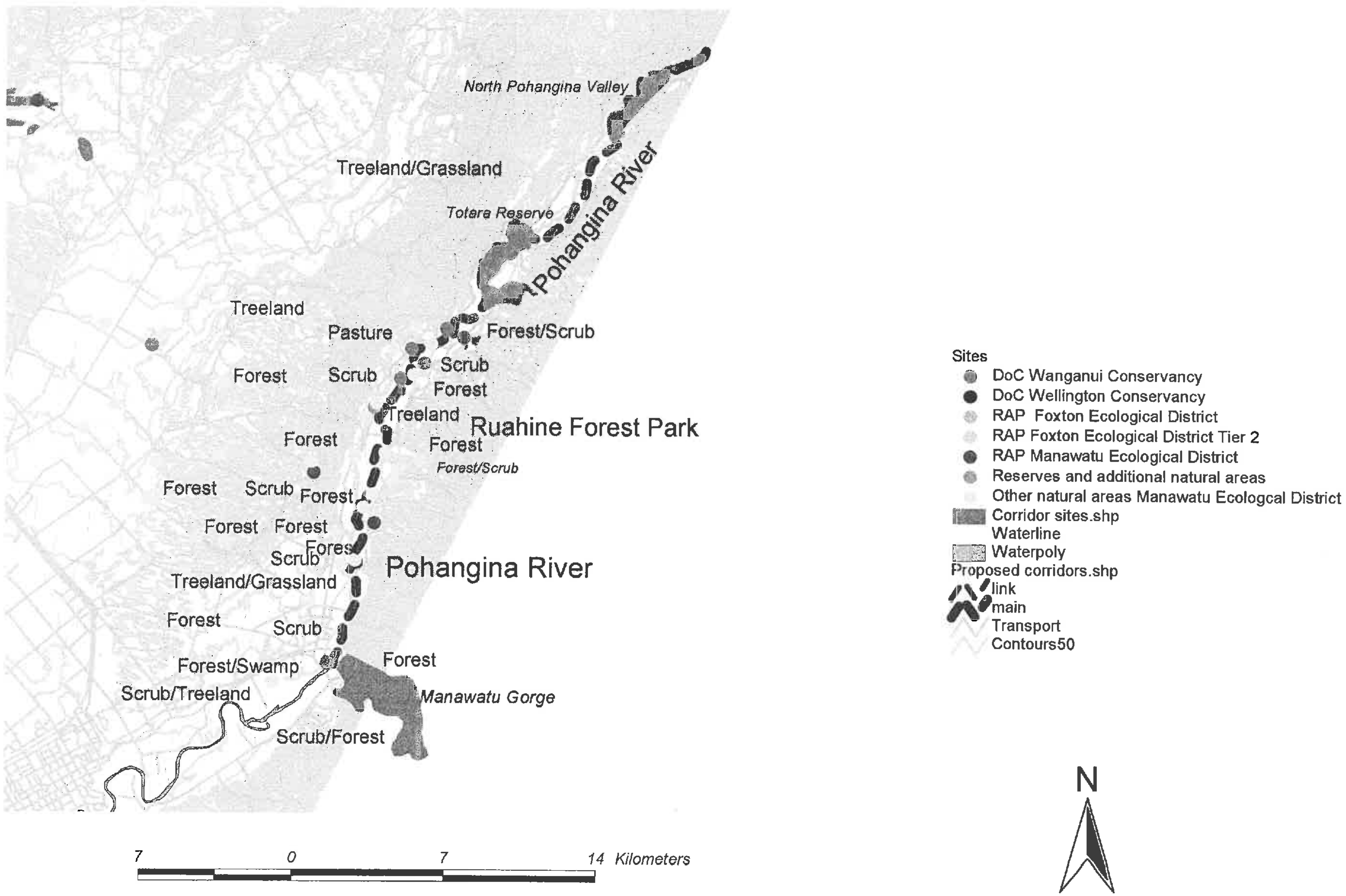
Map 4 Manawatu River Corridor



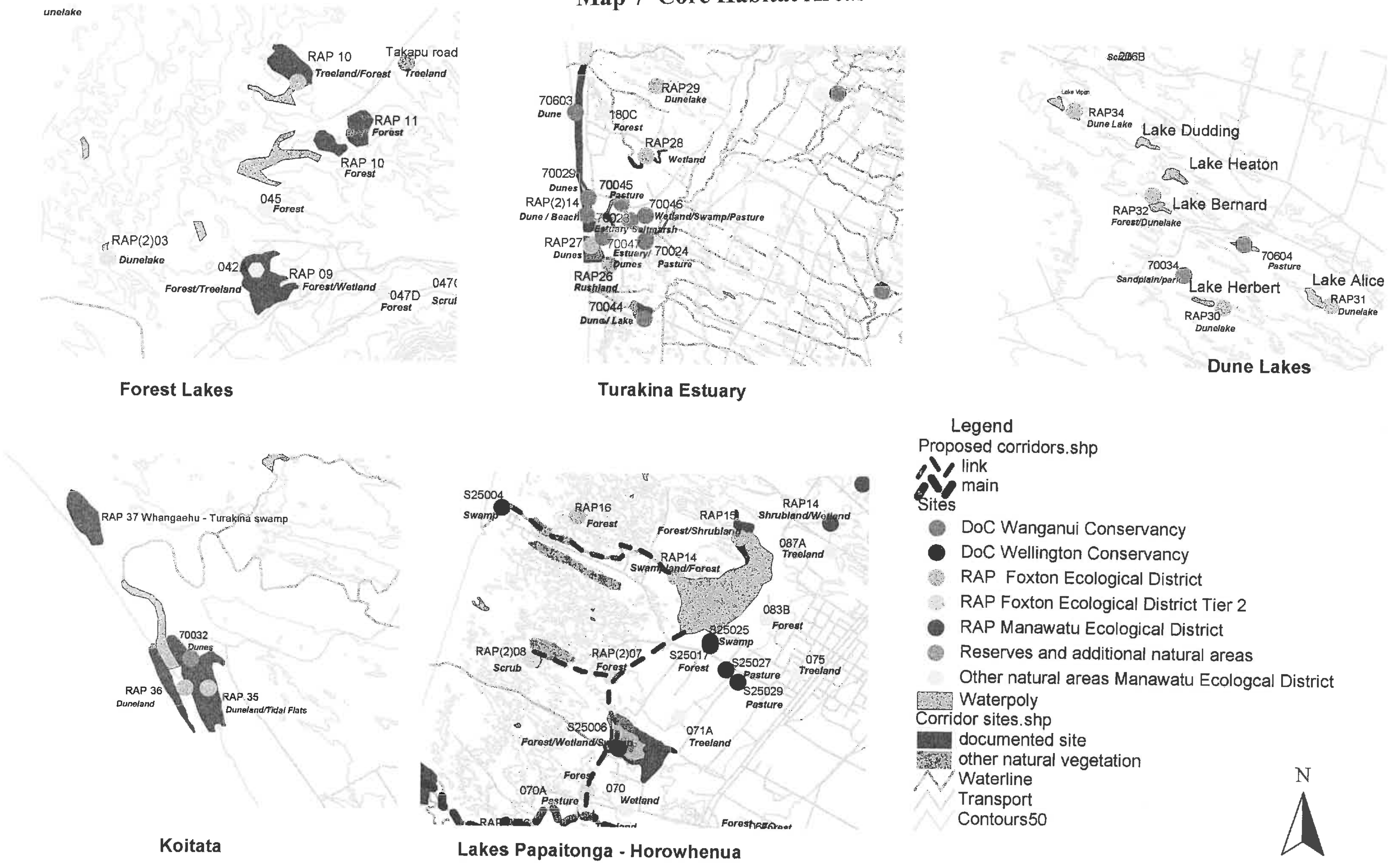
Map 5 Rangitikei River Corridor



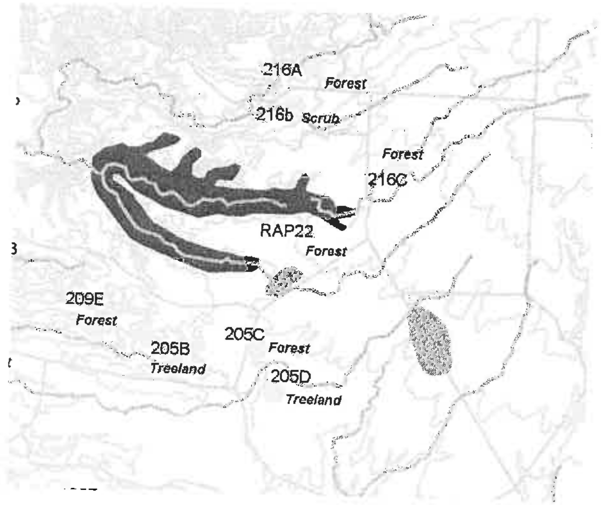
Map 6 Pohangina River Corridor



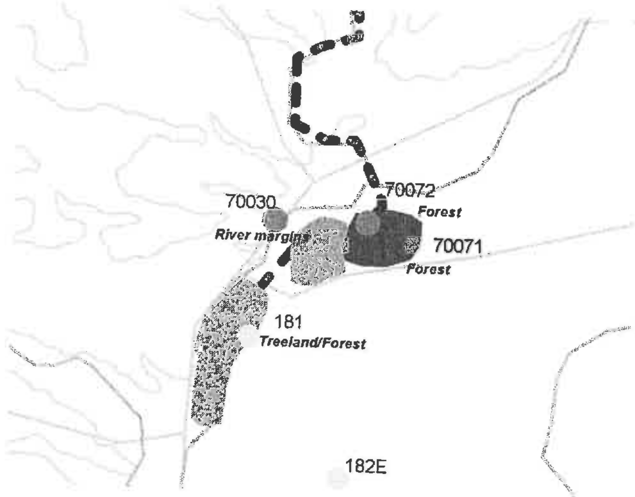
Map 7 Core Habitat Areas I



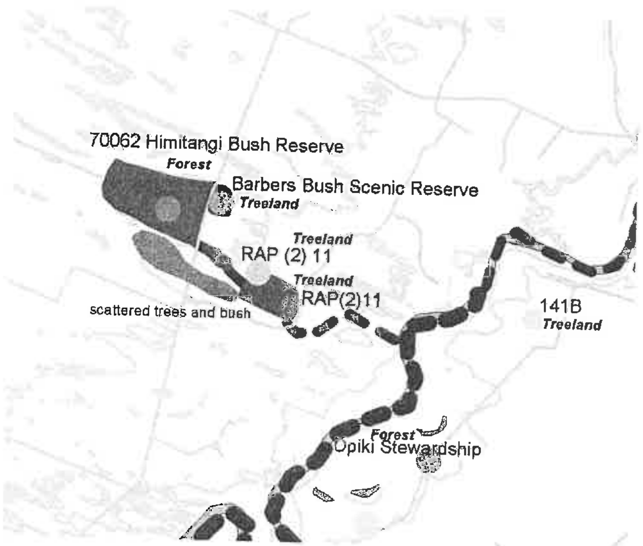
Map 8 Core Habitat Areas II



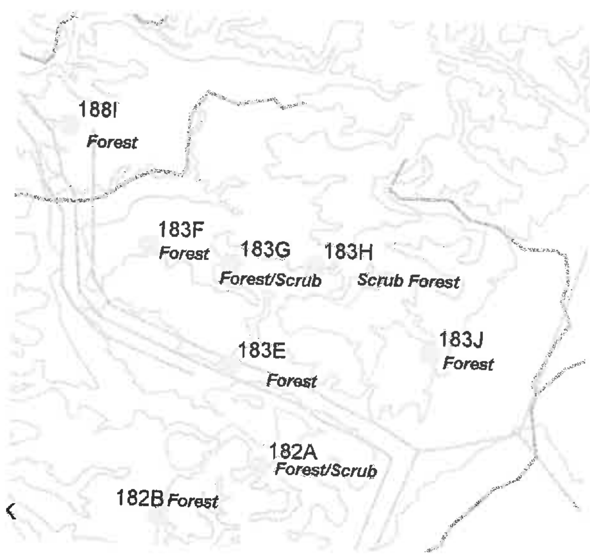
Gortons Bush



Kitchener Park



Himitangi Bush



Lethbridge Road