GREENWAY TO THE FUTURE?

THE USE OF GREENWAYS IN ROAD MANAGEMENT

A thesis

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ABSTRACT

Traditionally, roads have been viewed adversely in regard to the environment, and are considered one of the most serious threats to the landscape fragmentation process. This thesis examines the applicability of the greenway concept in New Zealand for enhancing the roading network, while providing connections to the surrounding landscape. Derived from the discipline of landscape ecology, the greenway concept advocates for a spatially structured landscape where corridors and stepping stones are designed to connect isolated patches.

Several methods have been used to gather information for this thesis. A comprehensive literature review provides a general overview of the greenway concept and the landscape and roading management regimes in New Zealand. Three case studies are investigated in two research phases. Firstly, institutional documents relevant to each case study are analysed to identify policy constraints and opportunities for greenway application in these areas. Map analysis constitutes the second analytical phase. The connectivity concept is applied to each case study area to determine the extent of connectivity within the case study landscapes, and the future implications of utilising roads as greenways in New Zealand.

Several conclusions were reached in this thesis. The greenway and connectivity concepts may be more applicable to significantly modified and fragmented landscapes than landscapes which are less modified. The following benefits may be derived from applying these concepts to New Zealand roads and landscape. First, connections between landscape elements are enhanced. Second, the connectivity concept can be used to prioritise landscape elements which require conservation. Third, the greenway and connectivity concepts can be used to mitigate the adverse environmental effects of the roading network.

However, the greenway and connectivity concepts are limited in their ability to influence road design - due to the overriding requirements of road safety. Greenway roads require extensive policy coordination between the agencies involved in landscape and road management. While DoC and regional councils offer potential opportunities to achieve such integration in New Zealand, the present policy situation reveals significant gaps in coordination, despite comprehensive requirements by the Resource Management Act 1991. Therefore, the application of the greenway concept to roads and landscapes in New Zealand requires changes within the present management regime.

ACKNOWLEDGEMENTS

There are many people to which I owe a great deal of thanks to, who have contributed to the preparation and completion of this thesis. First and foremost, I sincerely thank Dr. Jo Rosier, my supervisor, who provided an enormous amount of guidance, support and encouragement throughout the "thesis year". Her time and resources, including our excursions to the Pohangina Valley and Kapiti Coast, are much appreciated. Thank you Jo. I am extremely greatful for the help, resources and advice provided by staff in the Planning Department, especially during the last few weeks of thesis writing. Special thanks to Jane and Elaine, and Professor Phil McDermott and Dr. Claire Freeman for their comments during my mid-thesis crisis. A big thank you must also go to Karen Puklowski in the cartography section of the Geography Department for the wonderful diagrams.

I would like to acknowledge those people and organisations who provided information for this thesis. Thanks to the planning staff of the Kapiti Coast, Manawatu and Rangitikei District Councils for providing policy documents and reports in each case study area. Thank you also to the staff at Greening Australia, whose prompt attention enabled information to be received within a few days of request.

I would like to thank my parents, who have provided a huge amount of support. Thank you also for putting up with the large and sometimes unsightly sea of paper and books strewn throughout the house, and thanks also for proof reading the final thesis draft. I would also like to thank Richard for his patience and understanding throughout the thesis year. Finally, thanks to my predecessors whose theses have provided the much needed guidance towards the completion of this thesis.

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LIST OF ABBREVIATIONS

CMP	Conservation Management Plans
CMS	Conservation Management Strategies
DoC	Department of Conservation
EIA	Environmental Impact Assessment
FHF	Forest Heritage Fund
GW	Greenway
KCDC	Kapiti Coast District Council
LG Act	Local Government Act 1990
LWRRDC	Land & Water Resources Research & Development Corporation
MDC	Manawatu District Council
MWRC	Manawatu-Wanganui Regional Council
n/a	Not Applicable
PNA	Protected Natural Areas
RDC	Rangitikei District Council
RAP	Recommended Area for Protection [DoC]
RPS	Regional Policy Statement
RM Act	Resource Management Act 1991
SH 54	State Highway 54
SH 1	State Highway One
TNZ Act	Transit New Zealand Act 1989
WRC	Wellington Regional Council

GLOSSARY

Formally protected areas: Areas which are managed by formal protection mechanisms, such as reserves and covenants under the Reserves Management Act 1977 and Queen Elizabeth II National Trust Act 1977, or where there are legal conditions on resource consents relating to the area.

Informally protected areas: Areas which are identified in district plans or recommended for protection by DoC [RAP], but have no formal protection mechanisms or resource consent conditions relating to the area.

Mesic Interior: The innermost component of a patch or corridor.

Nodes: Nonlinear elements that can be considered to be a place or an event, for instance: patches, habitats, protected areas (Lineham et al. 1995).

Road: The strip of land along which vehicles travel. Roads usually have a paved or formed surface (Bennett, 1991:100).

Road Reserve: The total strip of land that is reserved for transportation purposes. There is usually a clearly defined boundary on either side of a road reserve where it abuts the adjacent land; but in some situations, such as forests or arid shrublands, the boundary may not be visibly defined (Ibid).

Roadside: The strip of land between the edge of the road and the adjacent boundary of the road reserve. The road "verge" or "right-of-way" are terms that are used elsewhere to refer to this land (bid).

CHAPTER ONE

INTRODUCTION

The panther's requirements in Florida,
Highlight the value of a corrida,
Without management and care,
To preserve what is there,
The New Zealand landscape will be horrida.
(Adapted from Gilfedder, cited in Saunders and Hobbs, 1991:69).

Landscape fragmentation, caused by the ever-increasing phenomenon of resource exploitation, has been identified as one of the most serious threats to biodiversity (Hay, 1991; Searns, 1995; Spellerberg, 1992; Stewart and Hutchings, 1996). Recognition of the acuteness of landscape fragmentation on biodiversity has resulted in concerned theorists requesting more sustainable landscapes, in which the needs of the present are met without compromising the ability of future needs to be met (Ahern, 1995). The "greenway" concept is one potential way to further sustainable landscape objectives.

The greenway idea has foundations in the discipline of landscape ecology. In order to remedy the effects of fragmentation, landscape ecologists suggest that future landscapes should be spatially structured by a "patch" and "corridor" spatial concept where corridors and stepping stones are designed to connect isolated patches (Ibid, 1995). Greenways is an essentially generic term that encompasses a wide range of linear landscape corridors, including: greenbelts, parkways, rivers, roads, canals, and abandoned railroads. Because of this diversity, greenways may serve a multitude of functions including: ecological, cultural, and recreational amenities (Hay, 1991).

While Little (1990) identifies over 120 greenway initiatives being implemented throughout America, the greenway concept is still in its infancy in New Zealand. Notable [and perhaps the only] examples of greenway application in New Zealand include: Christchurch City Council's Natural Environment Strategy where the Council proposes to "create a network of parks and open spaces connected by *greenways* or green corridors along riverbanks, walkways, disused railway lines and the edge of road reserves" (Briggs, 1996:9-10). Waitakere Eco City is another example where the Council is creating greenways through it's "Green Network", which involves "a continuous network of green extending from the West Coast, across the Waitakere Ranges to urban areas, linking bush, open space and streams" (Gordon, 1996:32).

This thesis examines the implications for using roads as greenways in New Zealand to enhance the roading network while achieving landscape connections. Therefore, greenways in this thesis can be considered as "a road reserve in which planting is conducted along the roadside to attain ecological objectives so that connectivity is achieved between landscape elements along the roadside and adjacent landscape". While other greenway objectives [such as recreation and amenity] will be achieved as well, they are not considered explicitly in this thesis, and further research would be required on these factors to provide a total picture of the implications associated with utilising roads as greenways.

WHY ROADS?

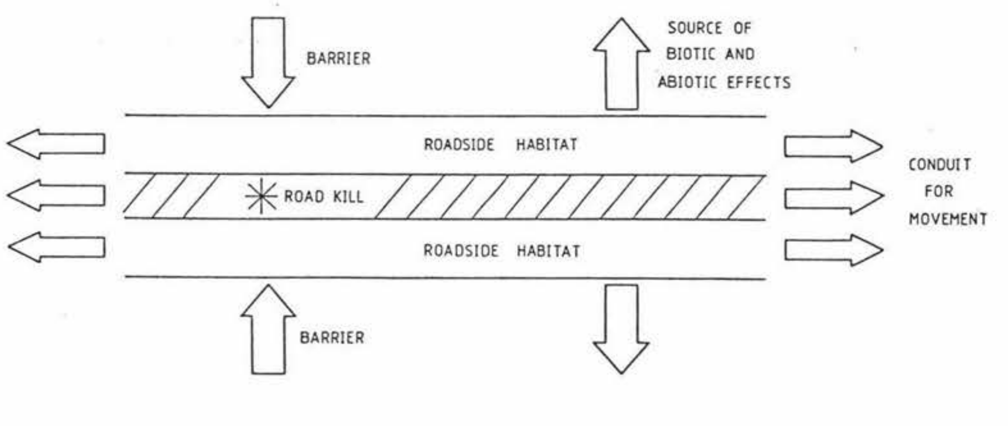
Roads can be defined as "transport corridors imposed on the environment by humans for the movement of people and materials" (Bennett, 1991:99) . Roads constitute the economic backbone of our nation and the vital link between our communities (Ministry of Transport, 1997:11). Consequently, the necessity to build roads is never understated (Kuiken, 1988), with road building activities normally taken for granted. However, roads can have a significant impact on the environment by cutting through areas of wildlife habitat and may be the single most destructive element in the habitat fragmentation process (Noss, 1993:60). As a result of this, roads have been traditionally viewed adversely in relation to the environment. Nevertheless, their linear nature enhances the potential of roads to serve as greenways by protecting and connecting landscapes of particular ecological, recreational and aesthetic value (Kent and Elliot, 1995). Management of roadside habitats has also the potential for restoring and enhancing connectivity to remnant natural elements in the landscape (Bennett, 1991). It is this value potential that will be analysed in this thesis.

Bennett (1991:99) identifies five major impacts that roads have on wildlife. These are shown on Figure 1.1 and are outlined briefly below.

- Road reserves provide habitat for wildlife. Road reserve vegetation has the greatest value as a wildlife habitat when it comprises remnant or regenerated strips of indigenous vegetation.

- Roads, roadside habitats and the aerial space above roads can facilitate the movement of animals along the direction of the road reserve.
- Road reserves can act as a filter or barrier to the movements of wildlife through the landscape, thus dividing and isolating populations to varying extents.
- Roads are a source of mortality for wildlife. For some species, particularly those that are large, rare, or are regularly brought into contact with busy roads (eg. migration pathways), road-kills can have a significant effect on conservation status.
- Road systems are a source of biotic and abiotic effects on the surrounding landscape. These effects include: vehicle emission of physical [eg. rubber, dust] and chemical [eg. carbon gases] pollution; hydrological changes [eg. the immediate road edge receives an elevated water input due to run-off]; and the interchange of biota between the road reserve and the adjacent landscape matrix [eg. animals using the roadside for shelter and nesting sites].

Figure 1.1 Diagrammatic representation of the relationship between road systems and wildlife (Source: Bennett, 1991:101)



Significant projects which are enhancing roadside corridors for wildlife movement include initiatives by "Greening Australia". This involves local councils working cooperatively with their communities and neighbouring councils in the management of local vegetation and biodiversity through "Local Greening Plans" (Greening Australia, 1995). For instance, the "Main Road 55" in New South Wales is managed as a conservation corridor, and guidelines as to how activities can proceed within the road reserve are provided (eg. Kulinskis, 1996). Additionally, roadsides in the wheatbelt of southwestern Australia are an important conservation resource for movement of species, and in particular, birdlife (Lynch and Saunders, 1991; Lynch, et al. 1996).

America is also an important initiator for using roads as greenways. Such roadsides serve scenic, historic and ecological purposes, such as providing corridors to permit wildlife movement into more expansive areas throughout America (Kent and Elliot, 1995; Little, 1990).

The conservation value of the New Zealand roadside has not been recognised to the same extent as the Australian or American roadside. The "Beautiful New Zealand" scheme, implemented by the New Zealand Government throughout the 1980s however, provided some recognition of the value roadsides contained. The scheme aimed to integrate roads and the adjoining countryside through landscape design and planting along the road reserve (Laws, 1987). However, the Beautiful New Zealand initiative concentrated more on using *groups* of road reserve plantings for aesthetics and road safety, as compared to this thesis which focuses on use of the road reserve for providing connections between landscape elements to achieve ecological objectives.

The benefits of the Beautiful New Zealand scheme include: the development of a sense of national pride; the provision of employment; a potential increase in honey production; advantages to the horticultural industry; and an increase in the biological value of roadsides. This latter benefit was seen as necessary to counter the under-represented state of New Zealand's conservation estate (Laws, 1987). This issue is discussed further in Chapter Three. Therefore, the enhancement of New Zealand's roadsides provides an enormous opportunity for attaining conservation objectives. This thesis offers a starting point as to how we can enhance roads as greenways so that connectivity is achieved between patches adjacent to the roadside.

THESIS AIM, OBJECTIVES AND RESEARCH QUESTIONS

The overriding aim of this thesis is:

To Investigate the Applicability of the Greenway Concept for Integrated Management of the Road Reserve and Adjacent Landscape in New Zealand

This aim is achieved by applying the greenway [and associated connectivity] concepts to three local case studies. The research is guided by three objectives and associated research questions.

OBJECTIVE ONE:

To explore the greenway concept.

Research Questions:

How has the greenway idea evolved?

What are the components of greenways?

How are greenways defined and classified?

What are the characteristics of greenways?

What are the advantages of greenways in landscape and road management?

What are the arguments against greenways, and how can they be remedied?

OBJECTIVE TWO:

To identify and understand the management regime of the landscape and roading network in State Highway 54, Pohangina Valley East Road and the Sandhills Bypass case studies, and in New Zealand generally.

Research Questions:

What are the issues relating to landscape protection in New Zealand?

What agencies are involved in the management of New Zealand's roading network and landscape?

What mechanisms are available to integrate management of the roading network and adjacent landscape?

What are the impediments to achieving greenway objectives in road design in New Zealand?

How are the case study roads and landscapes managed?

To what extent are greenway initiatives supported in the case study management regimes?

Are there gaps in policy between agencies involved in the management of the case study roads and landscapes?

OBJECTIVE THREE:

To apply the greenway and connectivity concepts to State Highway 54, Pohangina Valley East Road and the Sandhills Bypass to minimise the adverse environmental effects of these roads.

Research Questions:

What are the significant resources of each case study?

To what degree do the case studies exhibit greenway characteristics?

What are the opportunities and constraints provided by the existing landscape structure of each case study to achieving greenway objectives?
What are the benefits of applying the greenway and connectivity concepts to the New Zealand roading network and adjacent landscape?
How can the agencies involved in each case study attain greenway objectives?
To what extent does road design influence greenway roads?
What are the implications of future greenway roads in New Zealand?

RESEARCH DESIGN AND METHODOLOGY

Figure 1.2 illustrates the framework for research design and methodology used in this thesis. Research methods have been chosen for their suitability in achieving the thesis research objectives. A review of literature pertaining to the greenway concept constitutes the first research phase. Journals have been the dominant source of this information. A further review of literature was conducted on the landscape and roading management regimes in New Zealand. Information for this review was sought from written documents including legislation and policy documents. The empirical phase of research entailed examination of three case studies, where relevant institutional documents and topographic maps were used to gather information and analyse how applicable greenways are in the management of New Zealand's roading network. The detailed methodology for this analysis is discussed in Chapter Four. The research design and methodology of the second half of the empirical phase [topographic map analysis] is provided in Chapter Five.

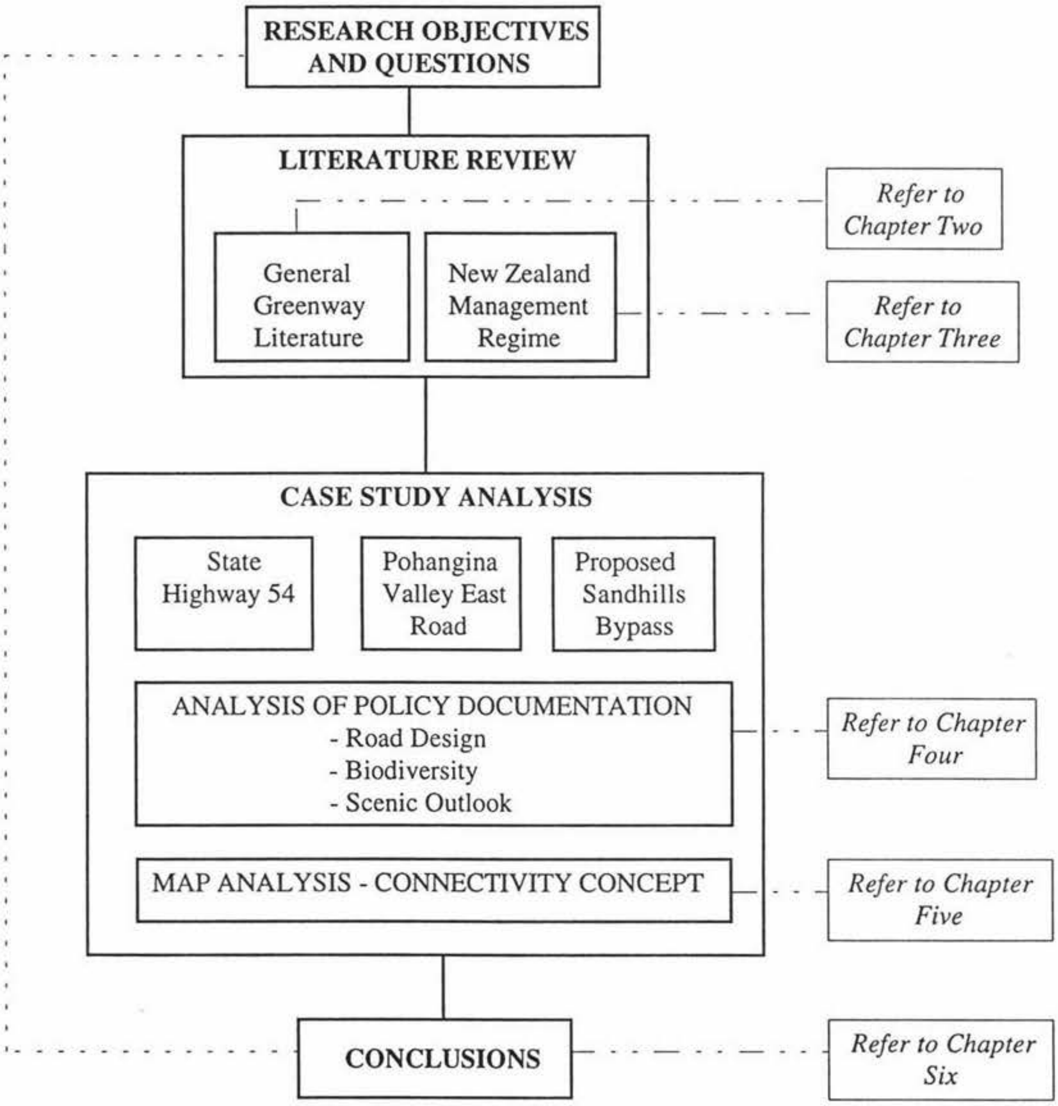
LITERATURE REVIEW

The literature review focuses on two major areas: the greenway concept, and landscape and road management in New Zealand.

Greenway Concept

A number of documents were analysed in the early stages of this thesis to provide a conceptual overview of the greenway concept. These included journal articles and books available in New Zealand, though some journal articles were located in Australia. The majority of these documents were of American origin since the greenway concept is still in its infancy in New Zealand. However, other countries have also provided examples of greenway initiatives, including Canada, England, Bulgaria, Portugal and Hungary (Fabos, 1995). A significant contributor of greenway literature has been the *Landscape and Urban Planning Journal*, which dedicates a whole issue to greenways. This journal issue was in fact a response to the lack of information on the greenway concept. Books not available at Massey University Library have been interloaned from various libraries around New Zealand.

Figure 1.2 Research Design and Methodology



New Zealand Management Regime

A wide range of literature is analysed on the landscape management regime in New Zealand. This information is derived from documents prepared by the Ministry for the Environment, the Department of Conservation, Royal Forest and Bird Protection Society, and various local authorities. A visit was made to the Department of

Conservation Library in Wellington during the earlier stages of the research. This provided some information on the available methods for conservation of public and private land [Appendix 1.2]. Several journal articles have been consulted which have helped to provide a critical analysis of the present landscape management practices in New Zealand. Many of these journal articles were derived from the "First Search" method on the Library computers at Massey University. A search in the "Ecological Abstracts" from 1993-1997 was undertaken, to ascertain what constitutes patches, corridors and the landscape matrix in New Zealand. This search revealed that there is a significant deficiency regarding ecological information about New Zealand's landscape. The Massey University Interloan Service has also provided books on landscape management in New Zealand.

Information on the New Zealand road management regime has been obtained from various documents by Transit New Zealand, the Ministry of Transport and Transfund New Zealand. A literature search on the engineering criteria of road design in New Zealand has identified a deficiency of accessible books on this topic. It was discovered that Transit New Zealand uses the Australian standards for this guidance, however these sources were not available for this thesis. Thus, some information on guidelines for roading design has been collected from overseas, and sometimes dated sources. The New Zealand government's "Beautiful New Zealand Scheme" has provided some guidance, though this mainly concerns the use of planting in relation to road safety.

EMPIRICAL RESEARCH

The empirical research component of this thesis involves the investigation of three illustrative case studies. The case study method is one of several strategies which can be used to collect empirical evidence in the social science domain. In fact, the case study is the basic building block of research design (Bouma, 1993:93). Yin (1989:20) identifies three situations where the case study method is the preferred strategy for research design. These are: when "how" or "why" questions are being asked, when the investigator has little or no control over events, and when the focus is on a contemporary phenomenon within some real-life context. The research aim in this thesis fits the first criterion as it seeks to explain *how* the greenway and connectivity concepts may be applied to achieve integrated management of the road reserve and adjacent landscape. Secondly, in contrast to experimental situations where the investigator can manipulate behaviour [for example in laboratory settings], the researcher has no control over the events or outcomes that were the object of research in this thesis. Thirdly, the focus of this research is on contemporary events as opposed to historical events.

The greatest criticism of case study research relates to a lack of rigor in this type of research. For example, case studies have often been conducted in a careless manner, allowing equivocal evidence or biased views to influence the direction of the findings and conclusions. However, similar biases can also be found in other research strategies, such as experiments, surveys or in conducting historical research (Yin, 1989).

As identified above, the research design involves three case studies. The major advantage of using multiple-case designs [studies which contain more than a single case] rather than single-case designs is that the evidence from multiple cases is often considered more compelling. Therefore, where multiple-case designs are used, the overall study is regarded as being more robust. Multiple-case designs, however, can require extensive resources and time. Thus, every case study should serve a specific purpose within the overall scope of inquiry (Yin, 1989:53).

Case Study Selection

The scope of the thesis research aim required more than one case study to be analysed. Three case studies were chosen so to provide a general and robust conclusion regarding the applicability of the greenway concept in New Zealand. As mentioned above, the use of multiple-case designs requires each case to serve a specific purpose. Therefore, the case studies vary in their characteristics so that more general conclusions can be made in regard to the New Zealand landscape. Case study selection was performed according to the following criteria:

- Differences in characteristics. For instance, whether or not the landscape is steep, gently undulating, or flat, offers different perspectives on how the greenway concept could be applied [Chapters One and Five];
- Road profile in relation to the landscape [for example, whether the road is *in* or *out* of the subject landscape [Chapter One and Figure 1.3];
- Proximity to significant ecological or aesthetic resources [Chapters One and Four];
- Similarity in length [Figure 4.1 and Chapter Four];
- Accessibility for study purposes.

All three selected case studies are located in the lower North Island of New Zealand [Map 1]. Figure 1.3 compares each of the road profiles in terms of how they are situated within the surrounding landscape. The first case study involves the northern part of State Highway 54. Due to the length of State Highway 54, the part under investigation was reduced to between Waituna West and Vinegar Hill. This segment of State Highway 54 follows an area of steep terrain and scenic beauty. There are several viewing opportunities along the route, the most notable being "Stormy Point", south of Rewa [Map 5.3A, Appendix 4].

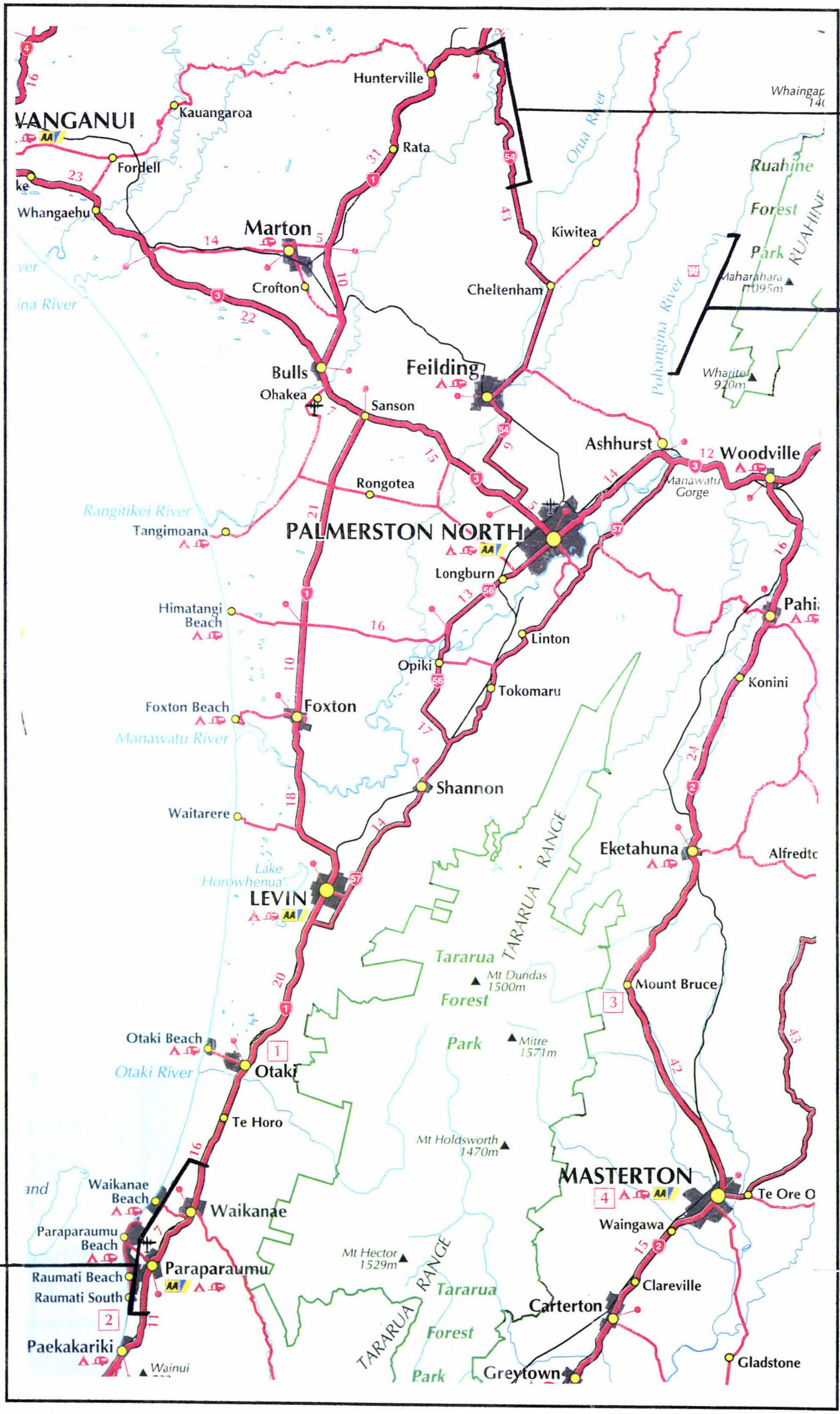
This vantage point has parking facilities and a viewing platform for people to take in views of Mt Ruapehu, Mt Taranaki, the Rangitikei River and associated streams, river terraces, floodplains, patches and corridors of indigenous and exotic bush, and rolling to steep farmland. These views are *out and over* from the road [Figure 1.3A]. Therefore, the important aesthetic resources in this case study are located away from the road. Hence, part of the road is not within the subject landscape. The road is a popular route for people traveling from the north [from State Highway One] to Feilding and surrounding localities, and is often used as an alternative to State Highway One [Map 1]. The Vinegar Hill Domain has important recreational resources [swimming and camping grounds], and the Paki-Rewa Golf Course and Rifle Club are located just south of the Vinegar Hill Domain [Map 5.3A, Appendix 4].

The Pohangina Valley East Road runs parallel to the Pohangina River on the eastern side of the Pohangina Valley. Figure 1.3B illustrates that, unlike State Highway 54, the road is located *in* the subject landscape. Therefore, most of the important resources are located close to the road. Views of the river valley are important in this landscape. Several potential vantage points along the road exist which provide spectacular views, but there are no stopping areas at these places for people to park and take in the view. The landscape encompassing Pohangina Valley East Road is typically flat to rolling and not as steep as State Highway 54. Although the route is predominantly used by residents, it is a popular tourist route for sightseers and those seeking recreation. There are picnic and swimming areas at Totara Reserve and Raumai. Totara Reserve also has camping and further recreational facilities. Highland Youth Camp offers accommodation in close proximity to Totara Reserve. The route is also used by people visiting Pohangina Village on the other side of the Pohangina Valley.

CASE STUDY ONE:
STATE HIGHWAY 54

CASE STUDY TWO:
POHANGINA VALLEY
EAST ROAD

CASE STUDY THREE:
SANDHILLS BYPASS



NORTH

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LEGEND:

Case Study Road	*CASE STUDY ONE: STATE HIGHWAY 54*

Note: Map Derived From:
New Zealand Automobile Association Inc
Edition 2, 1997
Scale: 1:600 000

Map Number 1
Location of Case Study Roads

Figure 1.3 Profile of Roads in Relation to Landscape

Figure 1.3A State Highway 54

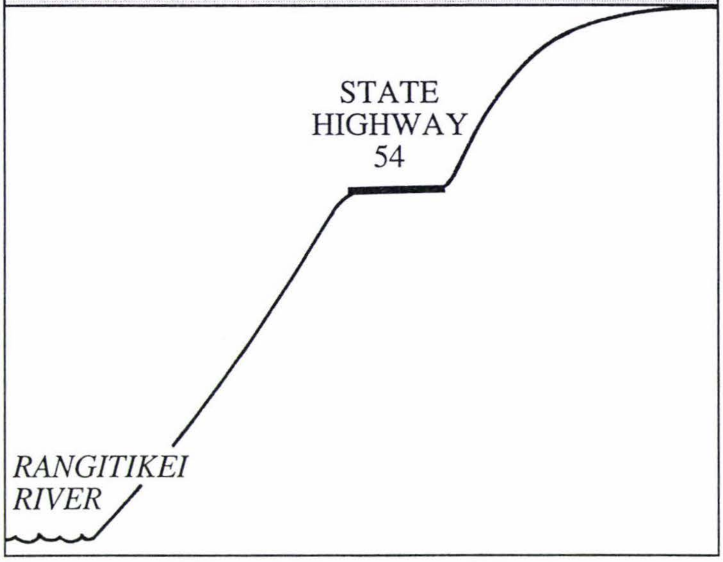


Figure 1.3B Pohangina East Road

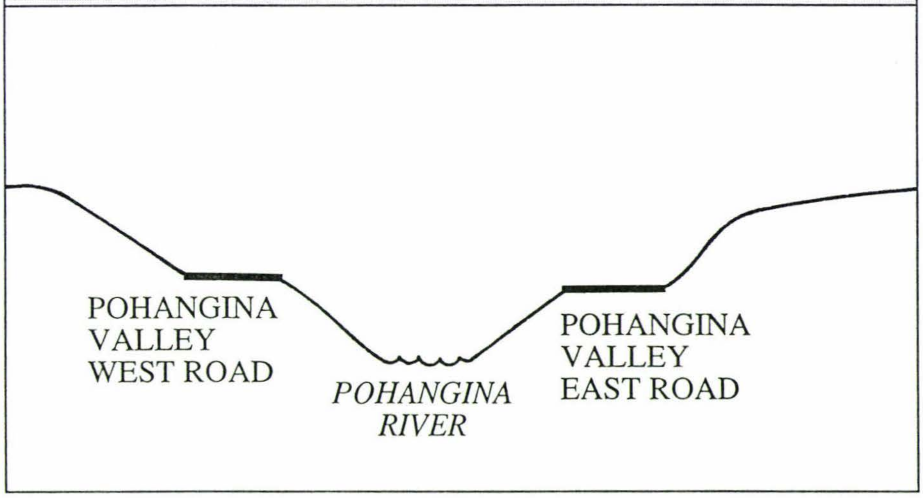
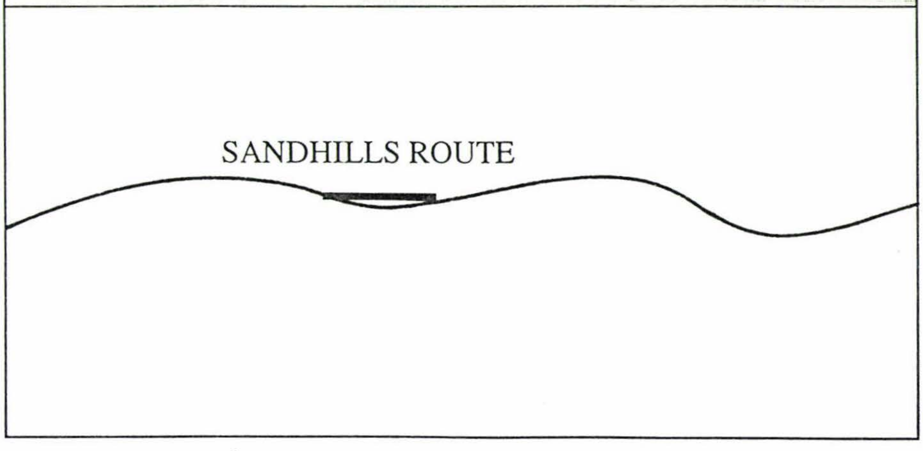


Figure 1.3C Proposed Sandhills Route



Case Study Three differs from the other two, in that it comprises a *proposed* route through an ecologically sensitive landscape of relic coastal dunes in the coastal environment. The Kapiti Coast District Council (1995) has designated a road corridor, named the "Sandhills Bypass", from Paekakariki to the Peka Peka Road intersection with State Highway One. However, a newer designation of the route is used in this thesis which runs from south of Poplar Avenue at Raumati South to the Peka Peka Road intersection (Opus International Consultants, 1997b). This designation is shown on Map 2. The purpose of the road would be to ease congestion along State Highway One, and to separate "through-traffic" from "local traffic" (KCDC, 1995). The character of this environment is moderately flat and therefore different than State Highway 54. As Figure 1.3C reveals, the proposed road is *in* the subject landscape, with any significant values located adjacent to the proposed route. Views are not important in this case study.

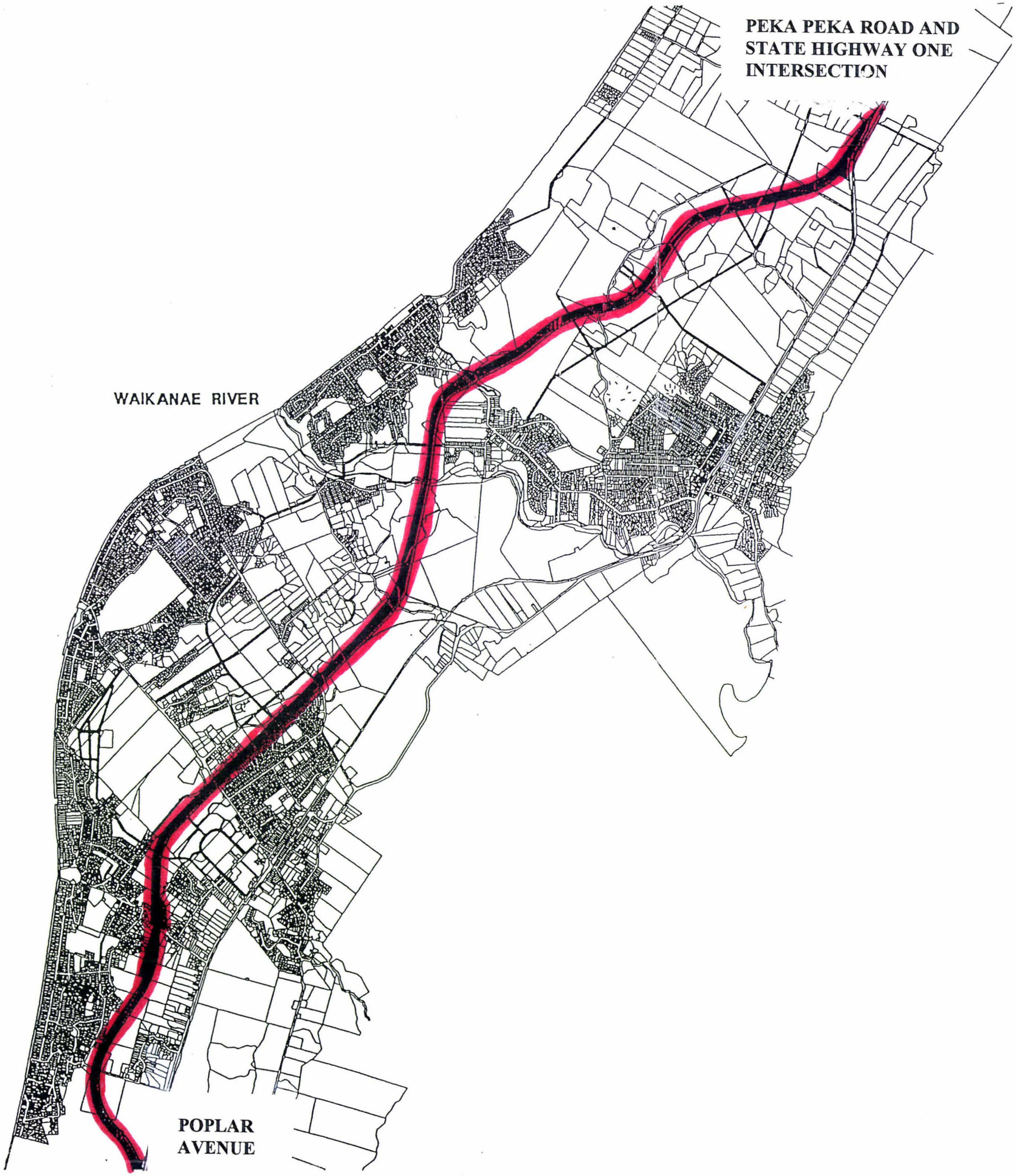
ANALYSIS OF INSTITUTIONAL DOCUMENTS AND MAPS

Institutional Documents

The first stage of the analysis phase entails analysis of the institutional documents used in the management of each case study location. These include: district plans, regional plans, and regional policy statements of the relevant local authorities. Department of Conservation documents, including Conservation Management Strategies and Protected Natural Areas Programmes, are also considered. Transit New Zealand documents are the primary source for information about road design guidelines and the roading management regime in New Zealand. The principal purpose of this analysis is to investigate the degree to which the relevant agencies support opportunities to apply greenway initiatives in the case study areas. As Figure 1.2 illustrates, this analysis uses three criteria relating to: road design, biodiversity and scenic outlook. This research phase is discussed further in Chapter Four.

Maps

According to Thorne (1993), the exercise of land-cover and land-ownership mapping is a prerequisite for understanding the context of greenway design. This exercise enables an assessment of the physical potential for linkage; the condition of the local matrix, patches and corridors; and the feasibility of implementing a corridor design.



NORTH

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LEGEND:
Proposed Kapiti Coast District Plan Designation of "Sandhills Bypass"

Note: Map Derived From:
Beca Carter Hollings & Ferner Ltd and Traffic Design Group Ltd (1996)
Scale: 1:50 000

Map Number 2
Designation of Sandhills Bypass

This thesis involves the analysis of topographical maps [New Zealand Topographical Map Series 260] to identify the vegetation patches and corridors in each of the case studies, and any constraints and opportunities in the surrounding landscape matrix for the placement of new patches and corridors in a potential greenway. This research phase and methodology is discussed further in Chapter Five [refer to Figures 5.1 and 5.2].

SCOPE OF THESIS

The aim of this thesis is to investigate the applicability of the greenway concept for integrated management of the road reserve and adjacent landscape in New Zealand. This thesis deals with the ecological significance of the greenway concept. However, while it is acknowledged that other greenway objectives could be achieved from the potential case study greenways [for instance: recreation and aesthetics], and that Maori concerns are also important, it is impractical to investigate all aspects of greenways in this thesis. Nonetheless, the 'synergising' characteristics of the greenway concept should assist Maori in achieving objectives relating to protection and enhancement of indigenous vegetation.

Outcomes of this thesis include recommendations to the agencies responsible for the management of the case study greenways. These include: local authorities involved, Department of Conservation and Transit New Zealand. It is recognised that there may be more agencies responsible for management. However, time constraints preclude consideration of other agencies at this time.

This thesis deals with the spatial analysis of the greenway concept only. Therefore, a planting plan and a list of species suitable for planting on roadsides is not provided.

PROBLEMS ENCOUNTERED DURING RESEARCH

DEFICIENCY OF ECOLOGICAL INFORMATION IN NEW ZEALAND

As outlined earlier this chapter, there is presently a dearth of ecological information on New Zealand's ecosystems. This includes a lack of available research into various aspects of landscape ecology in the New Zealand landscape (Gordon, 1996). For instance, little is known about the movement of wildlife in the New Zealand landscape and about the implications of edge effects, fragmentation and disturbance in our ecosystems (Norton, 1991). Consequently, the analysis in this thesis uses theoretical assumptions based on ecological information from northern hemisphere countries [for example Fedorowick (1993) in Chapter Five]. The implications of using theoretical assumptions derived in landscapes with different characteristics is emphasised by the following issue.

THE UNIQUENESS OF NEW ZEALAND

Geologic history has provided New Zealand with a unique situation where birds dominate the indigenous fauna. New Zealand had separated from Gondwana before mammals evolved, therefore, New Zealand ecosystems originally contained no land mammals apart from two species of small bats (DoC, 1994b; Norton, 1991). As a result of this, flightless birds and insects evolved to occupy niches normally filled by mammals, plants evolved features protecting them from browsing birds rather than mammals, and birds evolved behaviour to avoid primarily diurnal avian predators rather than nocturnal mammals (Clout and Saunders, 1995). Mammals were introduced with the arrival of humans. In northern temperate countries, small mammals are generally the dominant indigenous species. Therefore, the New Zealand situation establishes very different conservation requirements than northern temperate countries, as New Zealand pest management is mostly concerned with small mammals [such as rats, possums and stoats] which contrasts those countries with a supremacy of native land mammals.

Since the majority of greenway literature is derived from sources located out of New Zealand [and where conservation requirements are essentially for small mammals], these issues become important in the design and management of corridors and patches. For instance, the analysis performed in Chapter Five uses Fedorowick's (1993) minimum distance of 500 metres for determining adequate wildlife movement throughout the case study landscapes. However, as discussed in Chapter Five, this requirement is based on the median distance small mammals will travel in the open. As mentioned above, small mammals are typically pests in the New Zealand landscape. Therefore, it is acknowledged that management problems [such as increased access for pests to conservation areas] may occur if these theoretical assumptions are applied in the New Zealand landscape, although these are not explicitly considered in this thesis.

THESIS OUTLINE

This thesis is divided into six main chapters. Chapter Two begins by establishing the theoretical context of greenways. The components which make up the greenway concept are then identified, followed by a brief exploration of how greenways have evolved through time. The chapter then outlines the advantages and disadvantages of greenways, including how the arguments against the concept can be remedied. The final component to Chapter Two reviews the definitions, characteristics and classifications of greenways which have been provided in greenway literature. A greenway typology is then developed which is based on the literature review conducted in Chapter Two.

Chapter Three introduces the management regime of the New Zealand roading network and the adjacent landscape. This chapter first discusses the requirement for the integration of conservation into land use systems. Secondly, the agencies and legislation involved in roading and landscape management are reviewed. This section also identifies opportunities where integration between road and landscape management can be achieved. The third component to this chapter identifies the road design elements and principles which must be taken into account when designing roads. This helps identify the impediments to achieving ecological objectives in greenway roads.

The fourth chapter introduces the case studies used in this thesis. Chapter Four then analyses the management regime of each road in relation to the extent of policy coordination between relevant agencies and the degree to which greenway initiatives are supported in policy documentation. This is analysed according to three criteria pretaining to: road design, management of biodiversity, and scenic outlook.

Chapter Five introduces the connectivity concept and analyses the applicability of the greenway and connectivity concepts to the case study roads. Firstly, the methodology followed when applying the connectivity concept to each case study is outlined. This includes assumptions of the analysis, information requirements, and the research steps required to analyse the degree of connectivity throughout each case study area. Each case study is then analysed in regard of their applicability to these concepts.

Chapter Six concludes the thesis by synthesising the major research findings. The chapter revisits the aim and objectives of the thesis, and discusses the adequacy of applying the greenway and connectivity concepts to future New Zealand roads. Recommendations are then offered to agencies involved in the management of the case study roads. Chapter Six also discusses the issues for future research that have been raised throughout this thesis.

CHAPTER TWO

GREENWAYS IN CONTEXT

As discussed in Chapter One, greenways are an emerging concept which can be applied to counter to effects of fragmentation in the landscape. To increase the understanding of greenways, this chapter reviews the literature on greenways. The review outlines the theoretical context of greenways including the components which make up the concept, and how the idea of greenways has evolved. The chapter will then identify the advantages and disadvantages of greenways, and where possible, how the disadvantages can be remedied. The final part of this chapter examines how greenways have been defined and categorised by greenway authors to develop a greenway typology.

THEORETICAL CONTEXT OF GREENWAYS

Greenways can be considered as linear networks of land, composed of corridors, which are linked to nodes, or patches within the surrounding landscape matrix, thereby providing connectivity throughout the landscape. The greenway concept is derived from the theoretical context of landscape ecology. However, other disciplines, such as conservation biology, are also important. Landscape ecology is a multidisciplinary branch of modern ecology which deals with the interrelationship between humans [sic] and their open and built-up landscapes (Naveh and Lieberman, 1994).

Traditionally, protectors of biodiversity have considered landscape elements as isolated ecosystems and therefore have not recognised the linkages that exist with surrounding landscape elements (Forman, 1982). However, this approach is being criticised by several disciplines, including landscape ecology. For instance, typical conservation programmes [for instance, isolated protected areas] are often too small to meet the habitat requirements of some species, such as migratory species which cross broad geographic areas. These criticisms are in recognition of the need to address different time and geographic scales consistent with the biological, social and economic processes affecting achievement of conservation objectives. Instead, biodiversity objectives can be addressed more effectively by expanding the area to be managed beyond protected areas to the "landscape", "bioregional" or "ecosystem" scale (Heywood and Watson, 1996). This approach to biodiversity protection would include protected patches which are interconnected by corridors of habitat.

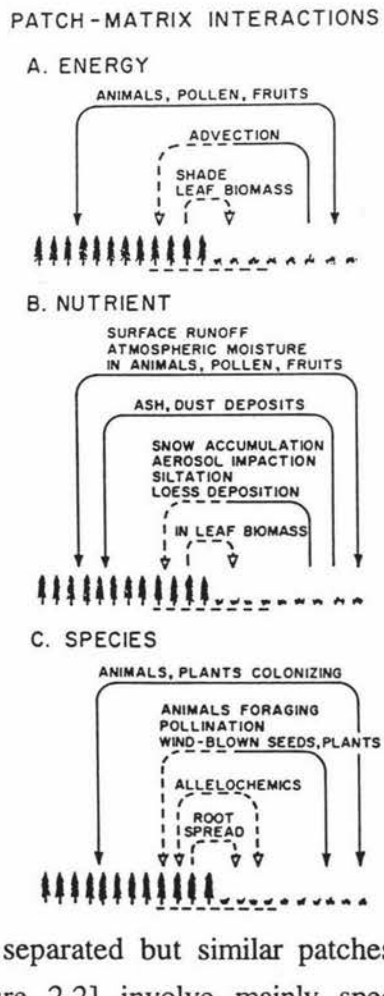
In landscape ecology, the fundamental goal of ecological design should be to maintain ecological integrity, or ecological health. Ecological integrity is broadly defined as "the degree to which ecosystems maintain natural processes and phenomena" (Smith, 1993:3). Thorne (1993:24) characterises ecological integrity by: natural levels of plant [primary] productivity; a high level of native biological diversity; natural [usually very low in sustainable landscapes] rates of soil erosion and nutrient loss; and clean water and healthy aquatic communities. Where natural conditions have been significantly altered by people, maintaining this ecological integrity requires careful design and management of many different landscape components. Greenways are one of these components.

Thorne (1993) identifies the landscape as a particularly useful unit for understanding broad-scale issues for ecological integrity. By understanding the nature of interactions across landscapes, it is possible to address systemic ecological issues over the long term. A review of landscape literature finds the word 'landscape' difficult to define. In response to this, Palka (1995:67) identifies four commonalities among contemporary definitions of the word, these being: an emphasis on that which is visible; an understanding that landscapes evolve through a process of human-land interaction; a recognition of a time dimension, as it pertains to landscape evolution; and a vagueness surrounding the spatial dimension or areal extent of a landscape.

A definition proposed by Forman and Godron (1986:11) introduces other elements, defining "landscape" as "*a heterogeneous land area composed of a cluster of interacting ecosystems that is repeated in similar form throughout*". Such ecosystems are called "landscape elements", which differ both in their appearance and in the way they influence ecological processes. Examples of landscape elements include: forests, houses or roads. Collectively, the arrangement of landscape elements is known as "landscape structure" (Dramstad, et al. 1996; Forman and Godron, 1986; Thorne, 1993).

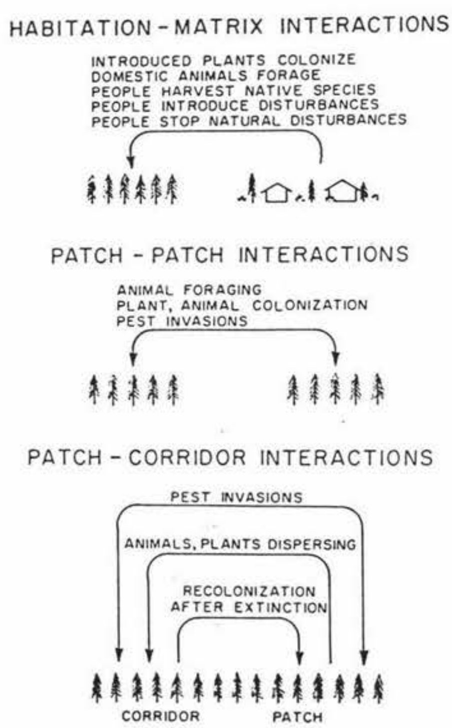
Within the landscape, interactions between landscape elements occur. These elements are defined and further discussed later in this chapter. Forman (1982) distinguishes three categories of things which move through a landscape: energy [calories in heat and biomass], mineral nutrients [inorganic ions, water, organic and other matter] and species [taxa at any level, as well as gene flow]. Energy is required to move all of these and is derived from: wind, water, flying and ground animals and people (Forman, 1982). Interactions between patches and the surrounding matrix are shown in Figure 2.1. In this figure, both the patch and matrix may be forested or open pasture. These interactions are typically highly significant and are usually driven by wind, water and locomotion. Where the patch is a human habitation [Figure 2.2], fluxes are primarily from patch to matrix, and depend on people and non-native species.

Figure 2.1 Landscape Interactions Between Patch and Matrix (Source: Forman, 1982:40)



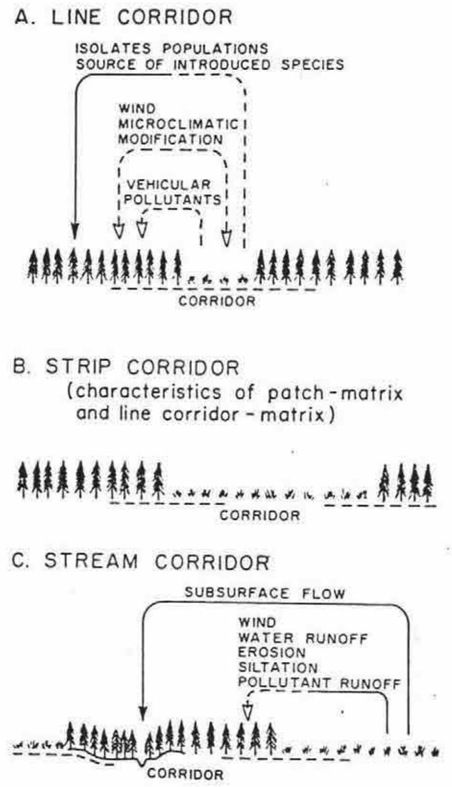
Interactions between two separated but similar patches, or between a patch and connecting corridor [Figure 2.2] involve mainly species fluxes, resulting from locomotion and wind (Forman, 1982). Corridor-matrix interactions depend on the type of corridor. Corridor types are defined and discussed in Table 2.1. The surrounding matrix exerts an overriding influence on line corridors, though beyond that, most of the interactions take place in the direction of corridor to matrix [Figure 2.3]. Line corridors may have the effect of isolating populations, therefore limiting gene flow. Fluxes between line corridors and the matrix typically involve energy, nutrients and species. Interactions between strip corridors and matrix display the interactive characteristics of both patch-matrix and line corridor-matrix interactions. Stream corridor-matrix interactions are characteristically unidirectional from the matrix to the stream corridor. Water and nutrient fluxes are the major fluxes, with water the primary force in these interactions.

Figure 2.2 Landscape Interactions Between Habitation and Matrix; Patch and Patch; and Patch and Corridor (Source: Forman, 1982:42)



The activities caused by the flow of energy, materials and species within landscapes are called "landscape functions". According to Fedorowick (1993:9), a diverse wildlife content is indicative of healthy soil, a good mix of crops and natural cover [for example in agricultural landscapes], and low levels of toxicants. Therefore, the ability of the landscape to sustain wildlife diversity represents adequate ecosystem [landscape] functioning. Over time, the flow of energy and consequent movement of materials in a landscape results in a new structure and new functional characteristics. This phenomenon is known as "landscape change" (Thorne, 1993). The discipline of landscape ecology focuses on landscape structure, function, and change of the landscape (Baschak and Brown, 1995; Dramstad, et al. 1996; Forman and Godron, 1986; Naveh and Lieberman, 1994).

Figure 2.3 Landscape Interactions Between Corridor Types
(Source: Forman, 1982:42)



LANDSCAPE ELEMENTS

Landscape ecology distinguishes three important landscape elements, based on the landscape ecological taxonomy explicated by Forman and Godron (1986). "Corridors" can be considered as linear landscape elements that differ in form from the matrix on either side (Forman and Godron, 1986:123; Thorne, 1993:26). Their function may be to interrupt or enable movement, depending on their orientation and configuration (Ahern, 1991). The surrounding landscape is known as the "matrix", which is the dominant cover type of a landscape, or the one that exerts the most control over landscape processes and change. Landscape function is primarily determined by the matrix (Ibid). Imbedded in the matrix are nonlinear landscape elements called "patches" (Thorne, 1993). Forman and Godron (1986:83) define patches as "a nonlinear surface area differing in appearance from its surroundings". The function of patches includes the provision of habitat islands which contribute to the maintenance of biodiversity (Ahern, 1991). Therefore, a network in landscape ecology is a system of patches and corridors existing within and abstracted from the landscape matrix (Lineham, et al., 1995). This description of the relationship of landscape structure to landscape function, makes landscape ecology a useful system for landscape planning.

The linkage of patches and corridors within the landscape matrix is crucial to the design of greenways. Greenways are primarily a type of corridor made up of linear arrangements of naturalistic landscape. Corridors are therefore the most significant landscape element when considering greenway design (Thorne, 1993).

CORRIDORS

Thorne (1993) identifies three important variables of corridor structure: width, connectivity, and quality. Corridor width determines how much of the corridor will be exposed to physical, human, and biological intrusions, or 'edge effects', from the outside. The 'edge' of a corridor will support different habitats than the corridor 'interior'. Connectivity is determined by the number and severity of breaks along a given stretch of corridor. Noss (1991:27) considers the concept of "connectivity" to involve "linkages of habitats, species, communities and ecological processes at multiple spatial and temporal scales". Corridor quality depends on width and connectivity, but also includes consideration of the structure of vegetation within the corridor. A corridor of optimal quality will typically have good vegetation layering, a variety of plant species, and minimal presence of aggressive, weedy vegetation. Landscapes that lack connectivity suffer from 'fragmentation', which results from the introduction of non-natural land cover types and the construction of roads.

While several corridor types have been identified, Forman and Godron (1986) distinguish a number of structural characteristics common to most types. Most corridors have a visible change in species composition from centre to edges. Additionally, corridors have a different central zone bounded by two side strips which may be similar, this being determined by the nature of the surrounding landscape elements. For example, the roadway of a highway, or water of a stream corridor constitute this central zone, and are used for the transportation of people, goods or resources. This zone also functions as a partial internal barrier between the two sides of the corridor (Forman and Godron, 1986).

Forman and Godron (1986) categorise corridors according to their structure. The classification is outlined in Table 2.1. Figure 2.3 illustrates each corridor. "Line corridors" are narrow bands essentially dominated throughout by edge species (Ibid, 1986). Line corridors are human-influenced, hence they require a considerable amount of maintenance. "Strip corridors" are distinguished from line corridors by their width. When the plant or animal community near the centre of the landscape element is similar to the interior community of a large forest, strip corridors become "patches" [discussed later]. "Stream corridors" control the movement of water and materials from the surrounding land to the stream and also influence transport in the stream itself (Forman and Godron, 1986).

Table 2.1 Corridor Type and Characteristics Identified by Forman and Godron (1986)

CHARACTERISTICS	CORRIDOR TYPE		
	LINE [eg. roads, hedgerows, property boundaries]	STRIP [eg. superhighways, wide strips of forest, wide power lines]	STREAM [a band of vegetation along a stream that differs from the surrounding matrix]
Frequency	Common	Not as common as line corridors	Common
Width	Narrow width [eg. <12 metres]	Wide [eg. >12 metres]	Varies according to size of stream
Structure	Narrow band dominated by edge species. Interior environment mostly nonexistent	Corridor wide enough to have an edge on either side of an interior environment which contains an abundance of interior organisms	Includes edges of stream channel, the flood plain, the banks above the flood plain, and part of the upland above the banks
Function	Limited as connectors between habitat patches; in case of roads: frequent use by people for transportation of goods	Routes for movement of terrestrial plants and animals across the landscape	Control water and mineral runoff, reduce flooding, siltation and soil fertility loss; routes for movement across landscape

Corridors can also be categorised according to their mode of origin. Loney and Hobbs (1991:300) recognise three types of corridors classified by this way. "Natural corridors" are present in unfragmented landscapes and may be retained following fragmentation. These include streams and rivers, riparian vegetation strips and topographic features [for instance, mountain passes]. "Remnant corridors" are strips of natural vegetation left following the clearing or alteration of the surrounding landscape. Roadsides and railway edges constitute remnant corridors. Natural corridors may also become remnants following landscape fragmentation. Cultural corridors are strips of artificial vegetation created specifically for a primary utilitarian use. These include: shelterbelts, hedgerows, ditches and clearings cut through forest and vegetation for power lines or rights of way.

Both of the above classifications identify roads as typical examples of corridor elements in the landscape. For instance, roads are linear in structure, pass through the surrounding matrix, and they frequently serve to link patches of habitat in the landscape. However, roads are anthropocentric in origin and differ from natural corridors [such as streams] since unlike natural corridors which tend to follow environmental or topographical contours, roads often transverse these contours and bisect a range of different habitats. Additionally, road corridors are sites of constant human activity, and they are maintained by a constant input of energy (Bennett, 1991).

PATCHES

The importance of patches is explicitly identified in greenways. Where the corridors provide the essential linkage and connectivity among landscape elements, patches function effectively as habitat islands to contribute to the maintenance of biodiversity (Ahern, 1991). As with corridors, the majority of literature on landscape patches is derived from Forman and Godron (1986), who provide a classification of patches based primarily on their origins or causative mechanisms. Table 2.2 outlines the types and associated characteristics of each patch, including stimulus, sequence of change, turnover rate, recovery time, and the resulting landscape. The 'turnover rate' is defined as: "the rate at which patches appear and disappear" (Forman and Godron, 1986). Corridors can also be classified according to their origin by the same classification [for example, Barrett and Bohlen, 1991]. Figures 2.1 and 2.2 illustrate the interactions between patches and other landscape elements.

Patch Size and Shape

Patch size and shape are important characteristics in defining the nature of patches. Forman and Godron (1986) recognise two characteristics which are influenced by patch size: energy and nutrients, and species. Generally, large patches contain more energy and mineral nutrients than smaller patches. However, differences occur between the edge portion of a patch and its interior. The outer band [edge] of a patch contains a different composition and abundance of species. This is known as the "edge effect". Several factors cause the edge to contain denser vegetation than the patch interior including: the higher availability of light at the edge and reduced plant competition of the open side. Yet, although remnant edge species are more plentiful, they are often shorter and the branches bent due to the increased light conditions.

Patch Type	Stimulus	Sequence of Change	Turnover Rate	Recovery Time	Resulting Landscape
Disturbance patch	Natural or human activities (avalanches, herbivore outbreaks, fires) causing a disturbance in small area of matrix	Population sizes of species change: 1. Rapidly - dropping sharply as result of death. Some species become extinct, some remain in lowered population sizes or in dormant forms; 2. Increase of surviving species; 3. Arrival of species previously absent. Continuance of all three stages until community stability, patch disappears.	High	Fast	Patch converges with surrounding matrix
Chronic/repeated disturbance patch	Human-induced activities (unplanted pasture repeatedly grazed) cause patch to be repeatedly disturbed	Above successional process is continually set back or restarted, resulting in stability	Low	Permanent until activities causing it change	Remains different from surrounding matrix; is in equilibrium with it
Remnant patch	Natural or human activities (patch of vegetation missed by fire) causes widespread disturbance surrounding a small area	Similar to successional process in disturbance patch.	High	Slow	Patch may be a species-poor mimic of original ecosystem
Chronic disturbance remnant patch	Mostly human activities (forest surrounded by agriculture) leaves remnant patch isolated for long period of time	Longer relaxation period, more species lost, than remnant patch	Low	Slow	Patch different from original matrix
Regenerated patch	Mostly human activities (new 'natural' forests in an agricultural landscape) causing a spot within a large area of chronic disturbance to become free of disturbance	Resembles successional process of disturbance patch	Slow	Permanent until activities causing it change	Different from surrounding matrix

Table 2.2 Patch Type and Characteristics Identified By Forman and Godron (1986)

Patch Type	Stimulus	Sequence of Change	Turnover Rate	Recovery Time	Resulting Landscape
Environmental resource patch	Unrelated to disturbance; organisms of patch differ from surrounding matrix because the environmental conditions of patch are different [eg. water in the landscape]	Successional processes of population fluctuation, immigration, and extinction are present, but at a low level	Low	Permanent	Different from surrounding matrix, is in equilibrium with it
Ephemeral patch	Caused by social interactions, or by normal, short-lived fluctuations in environmental factors [flock of birds in field]	Levels of biotic or abiotic change are frequent, and of such low intensity, that species have adapted to them	High	Fast	Converges with surrounding matrix
INTRODUCED PATCHES		Depends on maintenance activities of people			
Planted/animal patch	Introduction of plants/animals by humans [eg. wheat fields; pine plantations; golf courses; grazing of sheep or cattle]	NO MAINTENANCE: Similar to disturbance patch: area invaded by species from matrix, succession and ultimate disappearance of patch, though introduced species may exert dominance for period of time [pine plantation]; MAINTENANCE: prevents succession. Brief initial period of sharp change associated with disturbance, a long period of relative stability during maintenance activity, then second period of major change during abandonment and succession	High Low	Depends on maintenance activities of people	Convergence with surrounding matrix if maintenance activities cease
Home/habitation	Disturbance by humans [eg. house and associated yard, farm buildings and immediate surroundings]	Total elimination of natural ecosystem at that spot, followed by building construction and introduction of new species. Patch remains stable for long period of time before disappearing. When maintenance lags, rapid and large changes occur in introduced species population. When maintenance ceases, patch converges with surrounding matrix	Depends on maintenance activities of humans	Depends on maintenance activities of people	Convergence with surrounding matrix if maintenance activities cease

Table 2.2 [Continued]

Animals, such as rabbits and deer, also exist in higher densities in the edge environment (Forman and Godron, 1986; Soule, 1991).

Since edge communities contain denser vegetation, the nutrient storage in vegetation may also be greater than in the interior environment. However, Forman and Godron (1986) suggest that the nutrient storage in soil may be either greater or less in the edge than the interior. For instance, the accumulation of leaves and other plant materials may result in greater nutrient storage in the edge, while factors such as the loss of leaves by wind, may produce less nutrient storage in the same community.

Both patch shape and orientation are important in the dispersal and foraging of organisms across a landscape. The primary significance of shape in determining the nature of patches in a landscape is related to the "edge effect" (Forman and Godron, 1986). Forman and Godron identify how patch shape and size influences the edge effect in isodiametric and elongated patches. A large patch in the shape of a circle or square, will consist mostly of the interior, with only a thin edge band. A rectangular patch of similar area, however, will have less patch interior and more patch edge, while narrow patches of the same area may be all edge. Patches in the shape of rings, for instance altitudinal belts of vegetation, are also composed mostly of edge. Therefore, the ratio of edge habitat to interior habitat increases as fragment [patch] size decreases (Soule, 1991).

Thus, in planning at the landscape scale, connectivity between patches and corridors is critical to retaining ecological integrity (Merriam, 1991). This section has provided a theoretical context for the greenway concept, as well as identifying the important landscape elements which constitute the concept. The following section introduces the greenway concept, by providing a brief overview of the evolution of greenways.

GREENWAY EVOLUTION

The concept, while not always under the name of "greenway", dates back to the 1700s. The origin of the concept is thought to be a cross between the nineteenth-century use of the American term "parkway" [which derive from boulevards] and the British term "green belt" (Bischoff, 1995). As early as the 1860s, the landscape architect Frederick Law Olmsted recognised the great potential of linear open spaces for providing access to city parks and extending the benefits of parks into nearby neighbourhoods (Smith, 1993). Olmsted created parkways, such as those in New York [Prospect Park] and Boston [Emerald Necklace], as links between parks

(Turner, 1996a). These parkways were designed to provide an aesthetically pleasing means of traveling by foot, horseback, or carriage [and later the automobile] between various points in the city, or between cities (Hoover and Shannon, 1995).

Ebenezer Howard advanced the concept from Germany's royal highways and boulevards with the term green belt in the late 1890s (Ryder, 1995). Howard proposed to reunite English city and country by surrounding cities with a rural green belt (Hoover and Shannon, 1995). The green belt also intended to control community expansion, and serve as a buffer between communities (Zube, 1995). These features are what Searns (1995) has categorised as "Generation One" greenways, ranging from pre-1700s to around the 1960s. The greenway concept was further developed by the American regional planner Benton MacKaye, who combined the green belt concept with elements of the early parkways and urban open-space networks. In addition to surrounding cities with green space as a means of blocking urban sprawl, MacKaye suggested bisecting settled areas with spokes of green and including recreation as a primary use of these "open ways" (Smith, 1993).

Searns (1995) identifies the second generation of greenways which date from between the 1960s to 1985. These are characteristically trail-oriented, primarily recreational greenways and linear parks which provide access to rivers, streams, ridgelines, railbeds and other corridors within the urban fabric. This type of greenway is non-motorised; a response to the automobile domination of the American landscape.

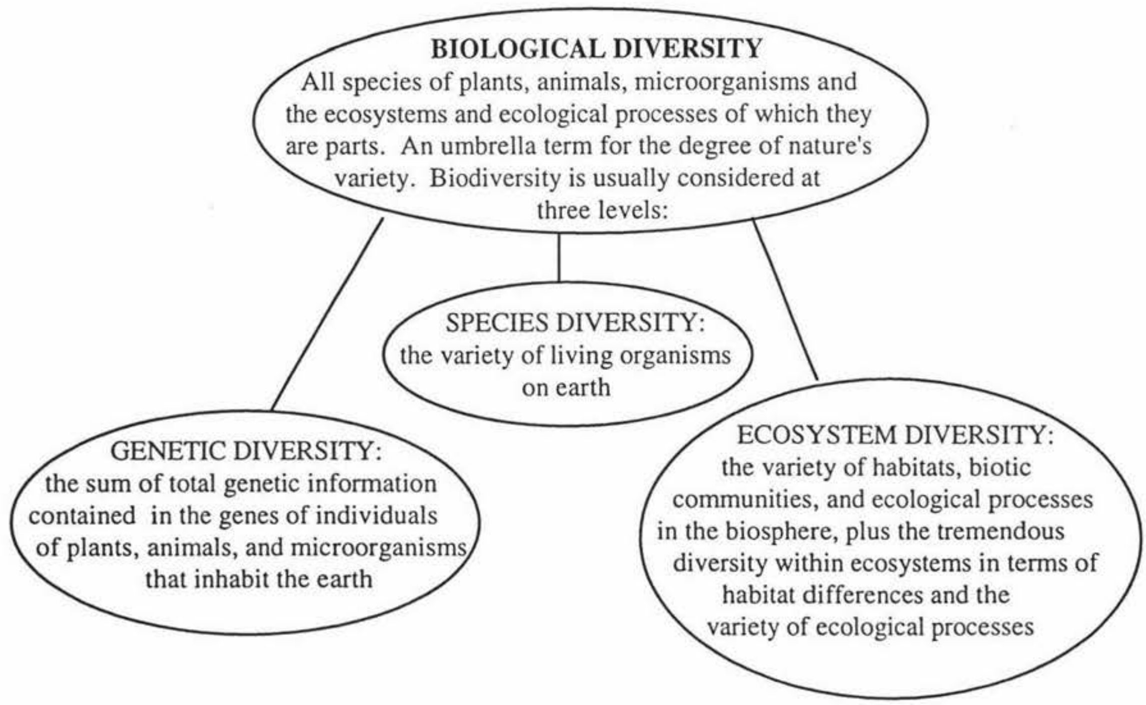
William Whyte is thought to be the first to coin the term "greenway". The term was used while preparing a greenway network plan for an undeveloped, semirural area of northwest Philadelphia. Whyte (1968), in: *The Last Landscape*, provided an explanation of the greenway idea. He wrote:

> "There are all sorts of opportunities to link separated [open] places together...Our metropolitan areas are crisscrossed with connective strips. Many are no longer in use...but they are there if we only look" (Whyte, 1968; Searns, 1995).

A common feature of the greenways described above is that they are primarily amenity oriented. These greenways were an adaptive response to offset and mitigate the effects of urbanisation. Their intentions were to provide alternative corridors which offer attractive visual form and, in most cases, greenery and solace (Searns, 1995). Although the third generation of greenways [circa 1985 and beyond] also have this function, Searns defines the most recent greenways as significantly broader in their goals. As well as abetting human needs, the notions of land and resource stewardship are now integral components of recent greenways, and the concept is still evolving.

Modern greenways are providing a new lease of life in the debate regarding the protection of biological diversity [biodiversity]. Figure 2.4 defines biodiversity and the three levels which make up the biodiversity concept. The loss of biodiversity at the ecosystem, species and gene levels has now become a global concern and an important land management goal (Hay, 1991). Issues such as global warming and its ecological and genetic importance, have lead scientists [for example conservation biologists] to conclude that resulting changes in habitats would cause the ranges of many species to shift outside the boundaries of parks and refuges now established to protect them. The creation of corridors between protected patches to provide travel routes has been recommended for preserving biodiversity (Ibid, 1991).

Figure 2.4 What is Biological Diversity?
(Source: Adapted from McNeely, et al. 1990)



Greenways are now seen as a potential tool to remedy land use effects, where corridors and stepping stones are used to connect isolated patches and thus help to counter the effects of fragmentation (Ahern, 1995). This new focus of greenways is complemented by an increased support of ecological information for the elements that make up the greenway concept, namely patches and corridors. There is now substantial backing regarding the ecological significance of a connected system of patches and corridors in the landscape, as this chapter reveals.

THE USEFULNESS OF GREENWAYS

This section discusses the usefulness of greenways in biodiversity protection, by outlining the arguments in favour of and against, the use of greenways as a planning tool. This discussion also helps to identify greenway functions and characteristics.

ARGUMENTS FOR GREENWAYS

As identified earlier, the strongest argument in favour of greenways is their potential role in improving the negative effects of landscape fragmentation (Ahern, 1995). Greenways, or "extensive open space systems" (Ahern, 1991), explicitly address the issue of landscape fragmentation through their emphasis on integration and connectivity. By providing higher levels of connectivity throughout the landscape, greenways are thought to enhance survival prospects for species. Connectivity enables certain species to migrate, disperse and repopulate patches in heterogeneous landscapes which may be alternatively occupied and empty.

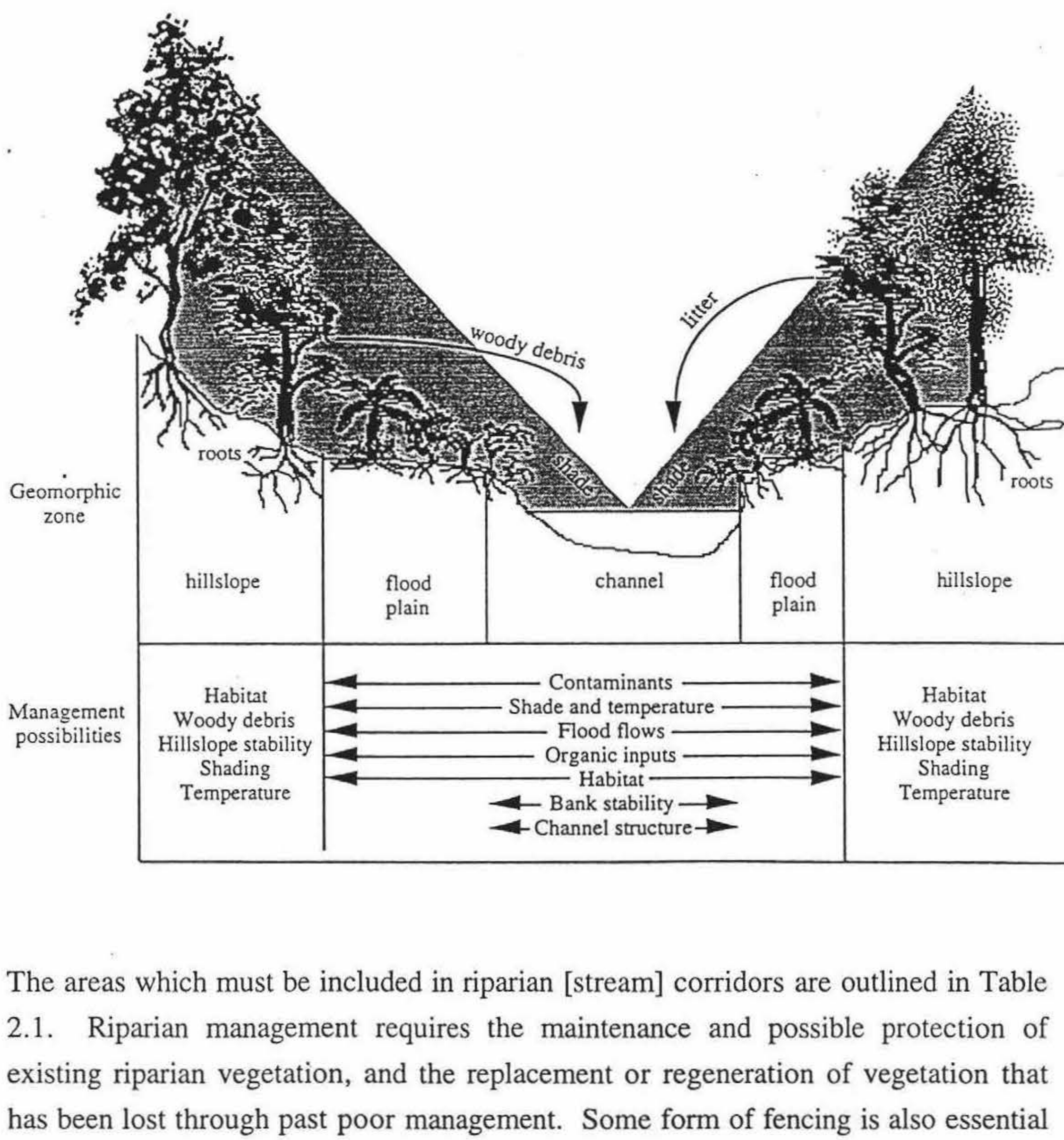
Potential advantages of increased species migration includes: an increase or maintenance of species richness and diversity; the increase in population sizes of particular species; a decreased probability of extinction; the permission of species re-establishment; the prevention of inbreeding depression; and the maintenance of genetic diversity (Lineham et al., 1995:181). Corridors can also increase the foraging area for wide ranging species, provide an escape cover for species movement between patches, increase the accessibility to a mix of habitats, and provide alternative refuge from large disturbances (Ibid, 1995). A planning tool such as greenways, which links suitable patches of habitat into a network of corridors, may therefore help achieve a more sustainable landscape condition in terms of biodiversity (Ahern, 1995).

Greenways have the capability to connect ecological and cultural resources into a type of network or system that may have greater value and higher use than the sum of the constituent parts - as a kind of landscape synergy (Ahern, 1995). The linkage of resources facilitates increased accessibility to a larger region of users, and through multiple use, may enable compatible uses within a single greenway. To aid understanding of this idea, Ahern (1991) uses the hierarchy theory from landscape ecology, which describes the relationships of elements within systems that simultaneously exist at multiple scales. The functioning of any such element contributes to, and is constrained by, the larger systems context in which it is nested. For example, certain ecological processes occur only in the context of large spatial or temporal scales, such as the example of the movement of large carnivores in developing landscapes. These species movements are enabled by extensive habitat networks and migration corridors [greenways]. The final benefits of these habitat corridor parts may exceed the sum of parts, in this case by providing for species that cannot exist within a limited habitat. The ideas of synergism is also identified by Zube (1995) where each characteristic of greenways combines with others to form a natural and cultural landscape matrix in which the whole is greater than the sum of the parts. Yet, both authors do not identify what "synergistic" properties are.

Furthermore, Ahern (1995) suggests greenways have the potential to provide a visible structure and legibility to the landscape. Lynch (1982) refers to legibility as "the degree to which the inhabitants of a settlement are able to communicate accurately to each other via its symbolic physical features", or "the ease in which [the cityscape's] parts can be recognised and can be organised into a coherent pattern". A legible landscape is important to provide a "sense of place" to its inhabitants. A "sense of place" is important for a community to develop a sensitivity to its unique heritage and environment, which may lead to protection of the resources which give the community its special sense of place (Rosenow and Pulsipher, 1979). If used as a form of regional scale design, greenways may have a significant impact on the physical and spatial character of the landscape. When a greenway produces a strong pattern and form in the landscape, certain natural features and processes may become more visible and legible.

Significant agricultural benefits have been identified from an interconnected patch-corridor system (Fedorowick, 1993). The inclusion of corridors in the landscape [for example: fencerows] inhibit runoff and erosion and increase nutrient recycling. Microclimatic benefits from corridors include a reduction in wind velocity, hence shade and shelter to stock is provided, and higher atmospheric and soil moisture (Ibid, 1993; LWRRDC, 1996a). Additionally, corridors along riparian margins [refer to "stream corridors", Table 2.1] provide numerous benefits to agriculture and ecosystems. Figure 2.5 defines the riparian zone and outlines the management possibilities in riparian margins. Riparian lands which have retained indigenous vegetation provide vital habitat for wildlife. In addition, water availability and soils which are rich in organic matter provide riparian lands with a high biodiversity. Riparian margins also play an important role as a corridor for the movement of plants and animals (LWRRDC, 1996b).

Figure 2.5 Riparian Zone: Geomorphic Zones and Management Possibilities (Source: Collier, et al. 1995:170)



The areas which must be included in riparian [stream] corridors are outlined in Table 2.1. Riparian management requires the maintenance and possible protection of existing riparian vegetation, and the replacement or regeneration of vegetation that has been lost through past poor management. Some form of fencing is also essential to control the access of stock and other animals to the water. Riparian management may additionally require action to control pest [animal and plant] species (LWRRDC, 1996b). The benefits for fencerows mentioned above are also provided by stream corridors. However, further agricultural and ecological benefits are possible through riparian management. For instance, improvements in water quality, the maintenance of river courses, and improvements in stock management [fences prevent stock from falling down riverbanks and fouling up waterways] can be achieved through riparian planting. In addition, insect pests can be reduced as riparian vegetation provides habitat for insect-eating birds and insect parasites. Generally healthier ecosystems, with increased fish stocks and decreased algal growth, will also be provided through riparian vegetation (LWRRDC, 1996a, 1996c).

Further combined agricultural and ecological benefits are provided by forest patches in low-lying areas. These patches can act as sinks for agricultural inputs and runoff and can also provide habitat for species that prey on farming pests (Fedorowick, 1993). Therefore, the introduction of greenways in fragmented rural landscapes can enhance both the human-induced [agricultural] activities and the landscape functioning [ecological aspects] of the ecosystem (Fedorowick, 1993).

Lewis (1964) advocates the importance of greenways [or what he calls environmental corridors] for their role in raising environmental awareness and knowledge, from local to regional levels. Environmental corridors can be considered the basic research units for recreational planning. In addition, they encourage planning for total environmental development, rather than for piecemeal and perhaps haphazard development.

The social benefits of greenways are identified by Luymes and Tamminga (1995) and Groome (1990). These include: nature education and routes for non-consumptive transportation modes such as walking and cycling. Greenways can also provide opportunities for the linkage of different parts of sprawling metropolitan regions. Additionally, Smith (1993) suggests that greenways add aesthetic appeal to the landscape. Greenways often follow natural physiographic corridors, such as streams, rivers, and ridges that have historical and cultural significance. Combined with aesthetic enhancement, this significance adds to the sense of history and culture that is important to people's experience of a landscape and their overall sense of place. Greenways can also link communities together by connecting features such as parks, historic sites, residential areas, and shopping districts, and by allowing people to travel from place to place without the noise and rush of automobiles (Ibid).

Furthermore, when designed to encircle cities and towns, greenways can function as green belts to help limit urban growth, abate pollution, provide recreational opportunities, enhance and protect scenery (Groome, 1990; Lineham, et al., 1995:181). Greenways also provide economic benefits such as: increasing property values when used as green belts (Bueno, et al. 1995; Lineham, et al. 1995); the development of tourism, which may be enhanced when a "sense of place" is created (Rosenow and Pulsipher, 1979); and the creation of employment and commercial opportunities (Bueno, et al. 1995).

ARGUMENTS AGAINST GREENWAYS

There is also some criticism against the use of greenways. When used as wildlife corridors, greenways have not been generally accepted by planners or ecologists. Daniels (1988) believes biological/wildlife corridors are not needed for three reasons. First, many species can disperse across the landscape without corridors. Second, there is a lack of evidence that the intended species will use the corridors. In fact, Turner (1996a:202) states that very few species have been shown to use corridors as their only or major means of dispersal. However, advocates for corridors argue that just because some inter-patch movements occur in the absence of intervening corridors does not mean that corridors lack conservation significance (Lynch et al, 1996). Rather, corridors function to enhance the ease and frequency of inter-patch movements.

Third, Daniels states that the corridors may expedite the spread of invasive species into protected areas. Diseases may also be spread through the linkage of corridors (Bueno et al. 1995; Thomas, 1991). In regard to the New Zealand landscape, Thomas (1991) suggests that the majority of introduced animals and plants, and the diseases they may harbour, are confined to, or more abundant in, human-modified environments. Thus this criticism is relevant when corridors are narrow and in environments that are susceptible to invasion of exotic species. Therefore, this concern could be counteracted by the design of wide corridors which enable species to pass between patches without coming into contact with the surrounding landscape matrix that contains the hostile species (Thomas, 1991). Additionally, instead of concentrating invasive weed management on the activities which cause the invasion, or times when weed invasion is most prolific [for example, competition during periods of recruitment by native species], Panetta and Hopkins (1991) suggest that management efforts should be put into the identification of "keystone" species which contribute most to degradative processes.

Further dangers associated with ecological restoration and reconnectivity have been identified. These include: increasing the immigration rate into reserves which could disrupt genetic adaptations to local conditions [outbreeding depression], and reducing genetic differences between populations (Thomas, 1991). However, advocates for corridors argue that corridors are intended only to maintain existing links and to re-establish links that existed until recently. Therefore, greenways should be designed to link only previously connected habitats - not naturally isolated ones (Hay, 1991; Thomas, 1991). These are aimed at permitting relatively natural levels of gene flow, therefore the advantages of corridors are likely to outweigh any problems arising from possible outbreeding depression.

Corridors may also facilitate the spread of fire, and may increase exposure to hunters and poachers (Lineham, et al., 1995; Thomas, 1991). Yet, regarding the first concern, corridors can also provide an escape route for animals when a disaster occurs in a patch in a connected network, and they also provide a recolonization route after the disaster has passed (Thomas, 1991). In New Zealand for instance, the endangered bird species of kokako was eliminated from the Omahuta forest by logging. As the forest slowly recovered, the kokako recolonised the forest from the adjacent Puketi forest, 40 years later. Since kokako are weak fliers, it is unlikely that they would recolonise isolated forest remnants. In regard to the second concern, the New Zealand landscape contains many introduced vertebrate pest species [Chapter One contains a discussion on this]. Therefore, the increased exposure to hunters and poachers may actually be beneficial in the New Zealand landscape (Ibid).

Bueno (et al, 1995) argues that an overall net positive effect from corridors is apparent, and that the negative risks may be reduced by the ecological management and restoration monitoring that is well researched and planned. For instance, patches can maintain more sustainable levels of landscape function through "patch edge buffering" (Ahern, 1995). This function protects patches of interior habitat from outside disturbances. Interior habitats are often non-fragmented patches of habitat for specialist species that cannot exist in highly disturbed and fragmented landscapes. If appropriately planned, designed and managed, the edge zones of interior patches can buffer or eliminate external disturbance factors such as, the spread of invasive non-native plant species into interior habitats. Maintenance of interior habitats [for example forest environments] is crucial to the protection of biodiversity.

Conservation biologists have also criticised the greenway concept (Ahern, 1995; Soule, 1991) Critics believe that by restoring and protecting connectivity of several small patches or ecosystems, we may open a kind of license to land use changes which may then continue to produce fragmentation of larger landscapes. Instead, skeptics advocate the protection of existing large patches in advance of fragmentation through additional protection, or through nature creation.

The imposition of greenways in a landscape has also the potential to lead to greater uniformity, including a loss of cultural landscape identity. For example, in open landscapes, inappropriate introduction of forested corridors can significantly change the physical, cultural, and visual landscape. This criticism is especially valid where the greenway network becomes a forested element in an otherwise open cultural landscape (Ahern, 1995:137).

Greenway planning should not be viewed as the only landscape planning action required (Ahern, 1995; Hay, 1991). The popularity of the idea may conceal or reduce other legitimate landscape planning issues and priorities, such as the protection of scarce resources, or the avoidance of landscape hazards. Instead, the greenway concept should be applied part of a larger and more comprehensive landscape/physical planning activity (Ahern, 1995).

Lastly, Groome (1990) stresses that greenways can be expensive to maintain compared with more conventionally shaped parks of similar area. For instance, if only a certain amount of money is available for protection, critics argue that it may be better to obtain further isolated habitat patches of greater intrinsic value, than to connect existing reserves where corridors contain only average habitat (Thomas, 1991). Yet, in many instances, the protection of a corridor does not preclude the preservation of another isolated patch, or vice versa - especially if the land is already publicly owned (Ibid, 1991). Additionally, critics state that corridor routes may be vulnerable to land use changes and their continuity can easily be interrupted by development for roading, housing, or industry. However, the validity of this last criticism is determined by the enforcement of planning controls.

These arguments reveal that, although greenways may often prove to be useful, they should always be understood in the overall context of the landscape to determine if the linkage is desirable or even necessary (Ahern, 1995; Thorne, 1993). The arguments against greenways are important matters which would need to be considered when maximising the use of road reserves as greenways.

DEFINITION OF GREENWAYS

The above section examines the usefulness of greenways in landscape protection. This section will provide an overview of how greenways are defined, characterised, and categorised by greenway authors. The aim of this section is to provide a typology of greenway types and their associated characteristics, so that understanding of the term is improved.

GREENWAY TYPOLOGIES

Greenways is essentially a generic term that has been applied to a wide range of landscape planning strategies, concepts and plans (Ahern, 1995). It is a term that can usefully be applied to many linear open spaces that have not traditionally been so named (Smith, 1993). Several authors have offered greenway definitions, yet a precise description is difficult because greenways take so many forms. Searns (1995) analysed the two root words, "green" and "way", to define the concept: "a vegetated, natural...route of movement for people, for animals, for seeds, and often for water". However, this definition is too simplistic in that it presents limited information on the characteristics of greenways. Table 2.3 provides an insight into the greenway concept by various greenway authors.

The earliest author to provide a valuable definition of the greenways concept was Little (1990). His definition in Table 2.3 reveals a broad range of greenway components. Little provides a typology of greenway types, based on primary greenway goals. Smith (1993) and Thorne (1993) provide a simple definition for the greenway concept. Little's (1990) definition is then used to expand this. The definition by Smith and Thorne is based primarily on ecological considerations [Table 2.3]. They distinguish between a spectrum of greenways, with recreation-based at one end, and wildlife corridors and streamside buffers at the other. Though, since their emphasis is on ecological greenways, Smith and Thorne do not further discuss recreation-based greenways. Four main types of greenways are identified. The classification by Smith and Thorne contrasts with other typologies, in that, instead of classifying the types of characteristics that may change over time or along a greenway's length [for instance the type of adjacent land use], physical and biological characteristics are used.

Three types of greenways are identified by Hoover and Shannon (1995) in Table 2.3. Since greenways characteristically follow natural landscape features, Hoover and Shannon outline the need for policy coordination across sometimes multiple jurisdictional boundaries in greenway protection efforts. This can be achieved through strengthening the existing organisational linkages or creating new ones, so that extensive, cross boundary public and governmental discussion of greenway issues can take place. If coordination between adjacent councils does not occur, degradation or even loss of the greenway and its dependent resources is possible (Ibid).

Author, Date	Definition	Greenway Types	General Characteristics	Information Needs	Implementation Issues
Charles Little (1990)	1. A linear open space established along either a natural corridor, such as a riverfront, stream valley, or ridgeline, or overland along a railroad ROW converted to recreational use, a canal, a scenic road, or other route; 2. Any natural or landscaped course for pedestrian or bicycle passage; 3. An open space connector linking parks, nature reserves, cultural features, or historic sites with each other and with populated areas; 4. Locally, certain strip or linear parks designated as a parkway or greenbelt	1. Urban riverside greenway [GW]; 2. Recreational GW; 3. Ecologically significant natural corridors; 4. Scenic and historic routes; 5. Comprehensive GW system or network	Linkage; Follow topographic logic of a place; Often unsuitable for land uses that would give them private economic value; Long and thin [linear]; Often strictly regulated to preclude certain kinds of uses; Often unsegmented; Provide longer edges than nonlinear open space; Mixture of public and private ownership	Large research base required: ecological, geological, hydrological, geographical, topographical, historic, ethnographic, land ownership inventory showing zones, land use constraints, subdivision requirements, public attitude surveys, economic studies	What organisational approach to use [eg: government focused; or private, nonproft organisations; or both of the above] Important to communicate and consult to wide audience early on. Public and protected land starting point; Complete each part of GW segment by segment. Who is responsible for maintenance - litter, signs etc? Financial help obtained from government grants, gifts of land etc.
Daniel Smith, James Thorne (1993)	Open space or natural areas that have linear from	1. Ridgetop corridors [high elevation habitat types]; 2. Upland corridors [forest interiors]; 3. Stream corridors [water resources]; 4. Connectors that cross elevational gradients for linkage of entire system	Linear shape; Incorporation of both conservation and recreational values	Ecological knowledge [eg how corridors function, how corridors interact with matrix]; Landscape context; Aesthetic preferences; Environmental constraints	Complexity of ownership patterns; Cost of acquisition; Funding; Management Plan necessary
Anne Hoover, Margaret Shannon (1995)	Corridors of private and public recreation lands and waters [whose purpose is] to provide people with access to open spaces close to where they live, and to link together the rural and urban spaces in the landsacpe	1. Recreation-oriented urban to rural linkage; 2. Rural GWs for protection of historical and cultural resources; 3. Rural GWs for protection of wildlife [wildlife corridors]	Linear configuration; Lengthy; Follow natural landscape features; Cross jurisdictional boundaries		Strengthening of existing organisational linkages or the creation of new ones, so that extensive cross boundary public and governmental discussion of public issues takes place

Table 2.3 Definition, Types, Characteristics, Information Needs and Implementation Issues of Greenways

Jack Ahern (1995)	Networks of land containing linear elements that are planned, designed, and managed for multiple purposes including ecological, recreational, cultural, aesthetic, or other purposes compatible with the concept of sustainable development	Typology defined by: Scale [Table 2.4]; Planning strategies [Figure 2.6]; Goals: 1. Maintenance or enhancement of biodiversity through habitat protection, creation, linkage, and management; 2. Protection, restoration and management of water resources; 3. Opportunities for natural resource-based recreation; 4. Linkage of cultural and historical resources	Linear; Provide linkage to the larger landscape context; Multifunctional; Complementarity between nature protection and economic development - consistent with sustainable development; A spatial strategy based on characteristics and advantages of integrated linear systems	Planning knowledge for protective and offensive strategies; Knowledge of ecological restoration for offensive strategy	Opportunistic planning strategy dependent on presence of certain landscape element; Protective strategy requires regulation and land acquisition; Defensive strategy is often reactionary and ineffective; Offensive strategy requires significant funding
Hay (1991)	A landscape linkage designed to connect open spaces to form protected corridors that follow natural and man-made terrain features and embrace ecological, cultural, and recreational amenities where applicable	1. Rivers through a city; 2. Paths and trails; 3. Ecological corridors; 4. Scenic drives and historic routes; 5. Greenway networks	Linkage central theme; Linear; Difficult to define due to diverse nature; Important in biodiversity protection; Often areas that can be acquired for little or no money	Ecological, geographic, historic, ethnographic studies, landownership; rights-of-way; zoning; open-space set-asides; public attitude surveys; public issues;	Public support critical to success; Requires a grass-roots, citizen-led, community effort; cooperative action
Tom Turner (1995), (1996a), (1996b)	A route which is good from an environmental point of view	Parkways [conversions of lightly trafficked streets, unused railway lines linking small and older parks]; Blueways [urban rivers]; Paveways [pedestrian lines]; Glazeways [continuous network in CBD]; Skyways [roof gardens linked]; Ecoways [networks of ecological space]; Cycleways [network of roofed, sheltered unwalked cycle paths]	The urban open space must be environmentally pleasant; Does not need to be "green"; Linkage	Expertise is required in designing and prescribing exactly the right type of GW; Contextualised to local circumstances	The GW type selected must be feasible within budget constraints

Table 2.3 [Continued]

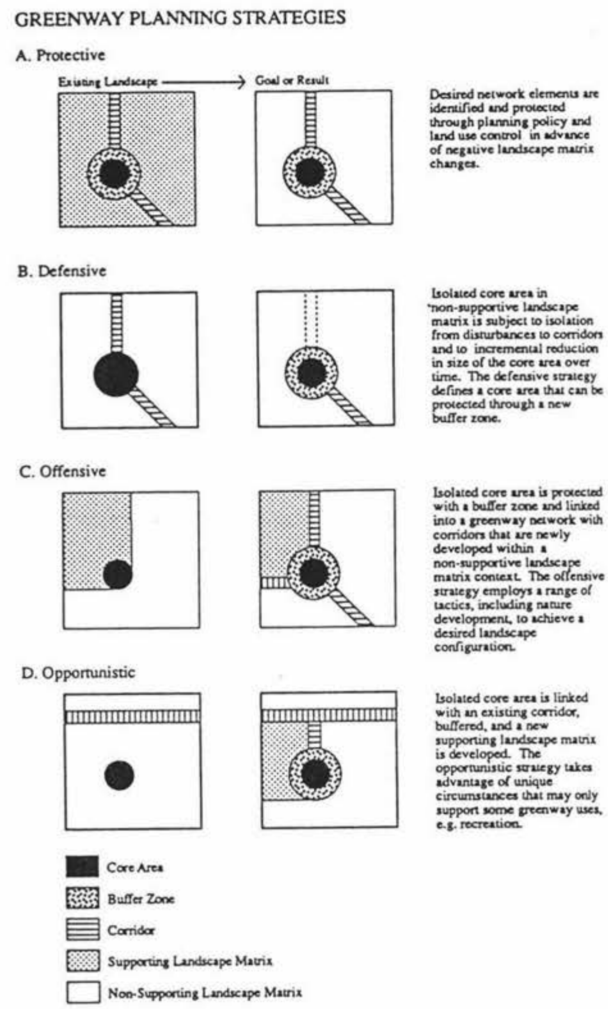
A greenway typology has been offered by Ahern (1995) to facilitate a more explicit understanding of greenways [Table 2.3]. The typology distinguishes four main characteristics of greenways: scale [outlined in Table 2.4]; goals; landscape context [which is not classified due to risk of oversimplification]; and planning strategies. Four planning strategies are distinguished in Figure 2.6. These include "protective strategies" which define an eventual greenway landscape pattern that is protected from change while the landscape around it may experience change. "Defensive strategies" are employed when the existing landscape is fragmented, and core areas already limited in area and isolated. "Offensive strategies" employ nature development to build new elements in previously disturbed or fragmented landscapes. Where the landscape contains unique elements or configurations that represent opportunities for greenway planning, an "opportunistic strategy" is applied. Opportunistic strategies may then be integrated with other strategies. These planning strategies reinforce the ideas presented earlier this chapter by Ahern (1995) regarding the "patch edge buffering" function of patches, and ideas by Forman and Godron (1986) relating to the importance of linkage throughout the landscape.

Table 2.4 Greenway Classification Based on Areal Scale and Associated Attributes (From Ahern, 1995:138)

Order	Area (km2)	Physiography	Political Units	Functional Orientation	Examples
1	1-100	Small streams Ridges	Municipal	Implementation Management	Platte River. Minute Man
2	100-10,000	Rivers Regional features	County Province	Coordination Policy	Quabbin N. Brabant
3	10,000-100,000	River basins Mountains	States Small Nations	Policy	Netherlands Georgia
4	>100,000	Continental	Large Nations and Continents	Policy	EECONET

Hay (1991) also provides a practical definition of the term "greenway", and differentiates five types which are similar to those identified by Little in Table 2.3. Hay highlights the importance public support in greenways, as the building of greenways requires a grass-roots, citizen-led community effort. Similar to Hoover and Shannon (1995), Hay also emphasises the need for a cooperative approach across governmental boundaries for greenway-building.

Figure 2.6 Greenway Planning Strategies Devised By Ahern (1995:140)



A simple greenway definition is offered by Turner (1995). This definition takes on board an extended current usage of the term [Table 2.3] where greenways "do not have to be green in mood" (Ibid, 1996a, 1996b). The greenway types identified in Table 2.3 are "fitted into the environment as carefully as the parts of a mechanical clock" (Ibid, 1996a:203). Turner argues that most greenways are bland strips of land, which do not lead from an origin to a destination, therefore are not "ways" in the historic sense of routes. Too much emphasis has been placed on planning open space which is "green" only in the sense of being vegetated (Ibid, 1995:269-270). Designers of greenways must therefore prescribe exactly the right type, contextualised to local circumstances, adapted to natural and human resource availability, feasible within budget constraints (Ibid, 1995:282).

Turner (1995) argues that the aim of landscape planning is to make good places, which are both useful, beautiful, and not necessarily green. To assist this process, the use of archetypes for specific varieties of "good place" is required. Building upon the methodology of pattern-assisted design [for example, Alexander's Pattern Language (Alexander, et al. 1977; Lynch, 1982)], Turner describes greenway types as archetypal patterns. For instance, an Alexander Pattern is a three-part rule, which expresses a relation between a certain context, a problem, and a solution (Turner, 1991). The different types of greenways identified by Turner are applied to this problem and solution format. Each greenway type is explained in terms of its relation to certain "larger" patterns which come above it in the language; and to certain "smaller" patterns which come below it in the language (Alexander, et al. 1977). Such linkage is an important characteristic of the greenway concept. However these greenway types are mostly relevant to the urban landscape, therefore they are not applicable to the greenways applied in this thesis.

Four common greenway characteristics are identified by the greenway theorists in Table 2.3. Greenways are primarily "linear" and are based on the characteristics or opportunities contained in linear systems. Their linearity distinguishes greenways from other landscape planning concepts (Ahern, 1995). A second characteristic is that greenways tend to "follow terrain features", including natural [rivers, ridgelines and floodplains] and man-made [roads, canals and railways]. "Linkage" is the central theme and goal of the greenway concept, where landscape elements are linked together to form a connected system. Table 2.3 reveals a diverse range of greenway types and functions. Greenways are also "multifunctional", based on a spatial or functional compatibility of certain uses [for example, recreation and wildlife habitat protection] (Ibid).

Table 2.3 provides an indication of the large information base required for the design and management of greenways. Extensive research is required regarding the landscape context in which the greenway will be placed. This includes not only environmental information [for instance, ecological, hydrological, topographical], but also information related to the social components of the landscape [including: historic, economic, public preferences and attitudes, land ownership, and planning constraints].

A number of issues are identified in Table 2.3 regarding the implementation of greenways. The most important issues to this thesis are as follows. The design of greenways should begin with determining the land which is already protected [for instance, for recreational or park purposes] and land which is publicly owned. This will constitute the starting point for creating the greenway corridor (Little, 1990). Consultation of landowners and the community early on is imperative to the success of greenways. Where consideration of landowners is left to later stages or even absent from the greenway-building process, landowners may view a proposed greenway as an encroachment on their property rights and may oppose the greenway (Ahern, 1995). The issues outlined in Appendix 1.1 regarding private property conservation would need to be addressed during the greenway-building process in New Zealand. Other implementation issues include how to source financial support, and determining who is responsible for maintenance of the greenway (Little, 1990).

CONCLUSIONS: TOWARDS A GREENWAY TYPOLOGY

Table 2.3 provides an overview of the different approaches authors have taken in describing greenways. Often, greenway types are classified according to their dominant goals, such as recreational or ecological protection. However, greenways can also be defined by their physical and biological characteristics, including ridgeline or streamside corridors. Definitions of the greenway concept reveal that the idea incorporates a diverse range of values, in both rural and urban environments, and natural and cultural landscapes.

Greenways can be considered networks of landscape corridors and patches, distinguished from the surrounding landscape matrix by their potential to provide tangible benefits to society, with only minimal modification to the landscape character. Greenways can be areas of environmental concern, or places of outstanding natural, historic, cultural, recreational and aesthetic values [for instance: sensitive wildlife areas, waterways, or places of high aesthetic value], which generally provide a "green" infrastructure to regional or local, urban or rural environments, while performing natural system functions.

This chapter reveals several universal characteristics of greenways. In summary, greenways are: primarily linear; provide linkage to the larger landscape context; are multifunctional; enable nature protection as well as economic development; follow both natural and man-made landscape features; cross jurisdictional boundaries, hence share a mixture of management responsibilities; are a mixture of public and private resource ownership; and lastly, do not have to be "green".

The multifunctional potential of greenways is identified in the wide range of greenways offered in the typologies discussed in this chapter. Table 2.3 distinguishes numerous greenway types with associated characteristics, which can be grouped into one typology [Table 2.5]. The typology distinguishes six types of greenways defined

Table 2.5 Typology of Greenway Types For this Thesis

Types Identified From Table 2.3	Forman & Godron (1986)	Characteristics and Functions of Greenways
Recreational Greenways	Line Strip Stream	Follow natural and cultural corridors; Rural and urban environments; General public access; High aesthetic values; Include: long distance paths, trails for walking, cycling, organised sports; may be linear urban parks along riversides, canals, towpaths, railroad right-of-ways; cycleways, skyways, paveways, glazeways, parkways, blueways
Scenic, Historic, Cultural Greenways	Line Strip Stream	Usually follow cultural corridors [eg: roads, highways], or natural corridors [eg: waterways]; Rural and urban environments; Link cultural and historic values; High aesthetic, cultural, historic values; General public access
Ecological Greenways	Line Strip Stream	Follow natural corridors [eg: rivers, streams, ridgelines]; Often in rural areas; High ecological and aesthetic values; Provide for biodiversity maintenance/enhancement through protection, creation, linkage and management of habitat; Enable nature studies, recreation, such as hiking; Often partial or total exclusion of public access; Include: ridgetop corridors, upland corridors, ecoways, blueways, wildlife corridors
Riparian Greenways	Stream	Follow natural corridors [eg: floodplains, stream corridors, groundwater recharge/discharge areas, wetlands]; Rural and urban environments; High aesthetic and ecological values; Often emphasise conservation [ie: protection of habitat], and/or recreation; Usually general access; Include: urban riverside greenways ie: run-down waterfronts, blueways
Urban Buffer Greenways	Strip	Follow natural corridors [eg: rivers] or cultural corridors [eg: urban boundaries] Between urban and rural environments; High aesthetic or ecological values; General public access; Development control and urban containment; Include: greenbelts, parkways
Greenway Networks	Line Strip Stream	Often follow natural corridors [eg: such as valleys, ridges]; or cultural corridors [eg: an assemblage of greenways and open spaces of different kinds to create local or regional infrastructure]; Cross elevational gradients for linkage of entire system; Can include all of the above

principally by their dominant purpose. Though, there is potential for overlap between each greenway type. For instance, recreational, scenic/historic/cultural, and ecological greenways can follow waterways, hence they may also be considered riparian greenways. On the other hand, riparian greenways can protect habitat and may therefore resemble ecological greenways. Since greenways can be established along either natural linear corridors or developed land, Table 2.5 distinguishes whether the greenway type follows natural or cultural land. Ecological and riparian greenways most commonly follow natural landscape features [for instance ridgelines or rivers], while the other greenway types are commonly found on both natural or cultural [for example roads, railways or canals] landscapes.

Table 2.5 incorporates Forman and Godron's (1986) classification of landscape corridors. Due to the overlapping nature of greenway types, most types constitute line, strip or stream corridors. Exceptions to this include riparian greenways [stream corridors], and urban buffer greenways [strip corridors]. In regard to urban buffer greenways, line corridors may be too narrow to function as buffers for urban development. In addition to corridors, each of the different patch types outlined in Table 2.2 may exist along any of these greenways, therefore patches have not been included Table 2.5. As identified in Chapter One, the greenways examined in this thesis involve "a road reserve in which planting is conducted along the roadside to attain ecological objectives so that the roading network is enhanced and connectivity is achieved between landscape elements along the roadside and adjacent landscape". Therefore, these greenways are a combination of "scenic/historic/cultural" greenways and "ecological greenways" identified in Table 2.5.

The following chapter will outline the management regime of the roading network and landscape in New Zealand. This will identify areas where integration between the roading corridor and adjacent landscape patches can be achieved. The impediments associated with road design in using future roads as greenways will also be discussed.

CHAPTER THREE

ROAD AND LANDSCAPE MANAGEMENT IN NEW ZEALAND

Chapter Three reviews the management regime of the roading network and the adjacent landscape in New Zealand in regard to management of patches and corridors. It is argued in this chapter that, at present, the New Zealand landscape is managed in a piecemeal way which often precludes effective protection of biodiversity and other values. Additionally, the landscape and roading network are managed independently, which affects the degree to which we can maximise the use of roads as greenways, and minimise the adverse environmental effects of the roading network on the landscape. Ultimately, integrated management of ecological values would require coordination between authorities who manage the road network and those who manage the private land adjacent to the road network. The agencies and legislation involved in road management and landscape protection are reviewed. To identify the impediments to achieving ecological objectives in road design, this chapter briefly outlines the road design elements and principles which road agencies must take into account when designing roads. These aspects of road design are expanded in Appendix 3. This discussion forms the basis for spatial analysis in later chapters of how greenways can be used to ameliorate the adverse environmental effects of roading.

INTEGRATION OF CONSERVATION INTO LAND USE SYSTEMS

Landscape conservation issues are of high importance to New Zealanders (Buhrs and Barlett, 1993). This may be a result of the close affiliation most New Zealanders have with the natural environment, and the fact that national symbols and national identity in New Zealand are associated with the natural environment, for instance: the Kiwi and Silver Fern. Additionally, for many New Zealanders [for example, Maori], the natural environment is also a source of inspiration and spirituality (Ibid, 1993; Marshall, 1994). Therefore, the conservation of scenic and natural values has ecological, cultural and spiritual significance. In order to maximise the use of roads as greenways, the integration of conservation values and road design and management would be required. However, despite the significance placed by New Zealanders on conservation of the natural environment, there is presently a lack of integration between conservation and land use, which plagues many conservation efforts.

According to Swaffield and O'Connor (1986) nature conservation in New Zealand has been provided for in an unrepresentative distribution. Traditionally, nature conservation has been set apart from, rather than integrated with, land use. People who use land for farm or timber production have seen themselves and their uses of land as separate from and generally in conflict with land use for nature conservation (Swaffield and O'Connor, 1986). A Taranaki Regional Council (1992) study on the protection of outstanding natural features and landscapes, finds that although New Zealanders are supportive of protection of natural ecosystems on the public estate, we are unfortunately less concerned about similar policies on private land, despite our "clean and green" image. Moreover, New Zealanders generally do not support initiatives for protection and enhancement, including restoration of degraded or destroyed natural areas.

For instance, lowland forest is greatly under-represented in the reserve system and frequently has been modified by past logging operations (Ogle, 1987). In general, mainland reserves of all types are dominated by subalpine and alpine areas of forest. Existing lowland reserves tend to be of small size, and are often on land such as coastal cliffs, river gorges, and other steep lands which had been uneconomic to clear, and which, by their topography, do not contain a representative selection of a region's biota. Rolling land, wetlands and flat land, which support different kinds [and generally a richer variety] of plant and animal life, are relatively poorly represented (Laws, 1987). A consequence of this lack of representativeness in existing reserves is that the survival of a number of species of indigenous animals and plants is not adequately assured (Ogle, 1987). Therefore, integration of nature conservation into local land use patterns has become imperative. The Department of Conservation [DoC] has attempted to address these problems by the introduction of the Protected Natural Areas Programme [PNA Programme], where remaining unprotected areas are being surveyed to ascertain representative areas that should be protected (Norton, 1991). The PNA Programme is conducted regardless of property rights. Appendix 1.1 outlines some of the pressing issues associated with private property conservation in New Zealand.

The ecological importance of roadsides has been discussed in Chapter One. In modified landscapes, management of roadside habitats has the potential for restoring and enhancing connectivity to remnant patches in the landscape. This potential is enhanced by the reserved status of roads as public land, their geographical extent and their network structure (Bennett, 1991). Thus, the management of roads as greenways contains significant potential for achieving partial integration between conservation and land use systems.

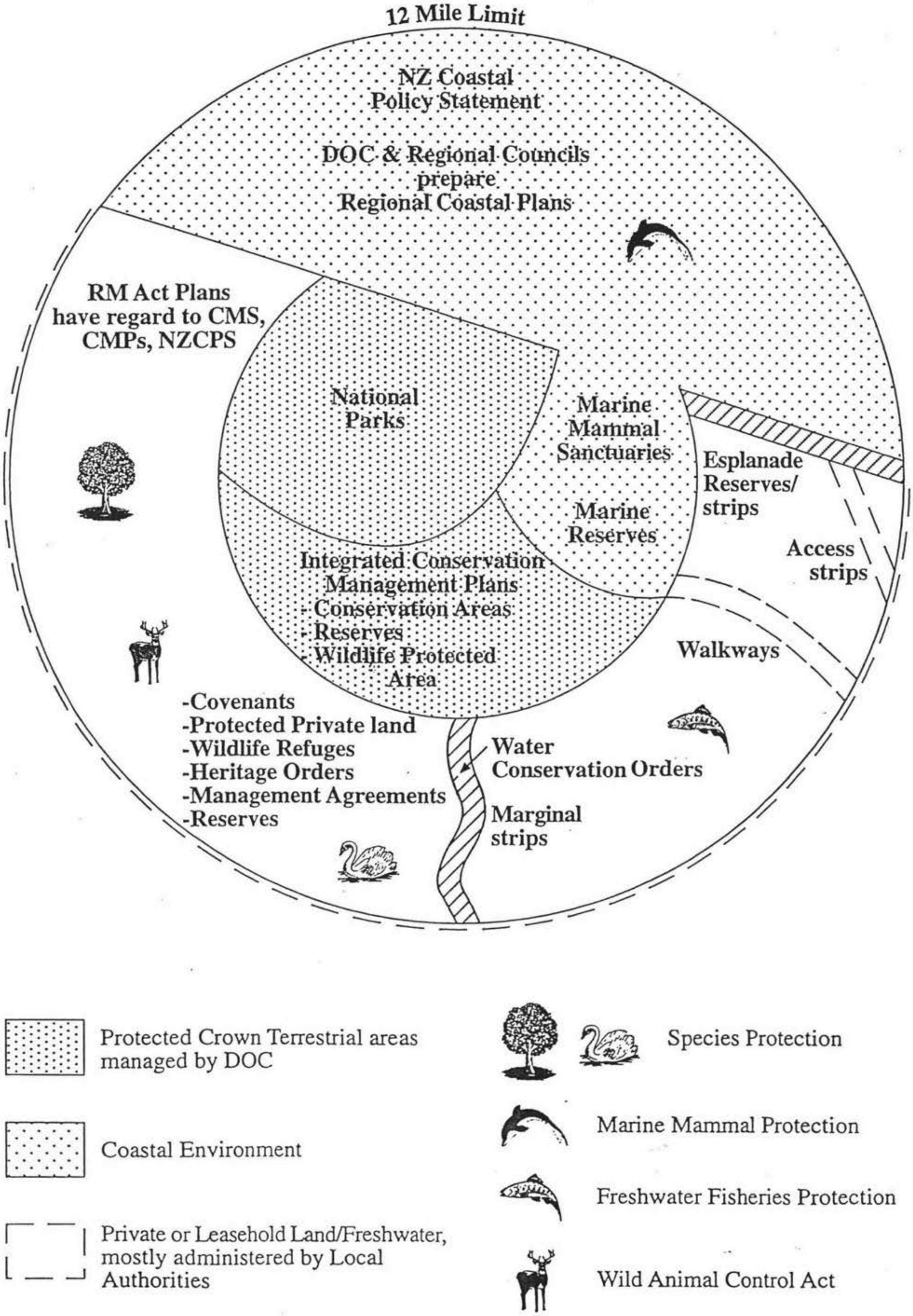
CONFLICTING USES OF ROADS

The public nature of the road reserve enables many different activities to occur between the fenceline boundaries. In general, roads are designed with transportational uses [for example: the movement of people, goods and services] as the highest priority and only where there are sufficient resources remaining after transportational requirements are fulfilled, can non-transportational activities be provided (Cooper, 1991). Possible non-transportational activities include: firewood collection; utility easements; the removal of soils from the roadside for private use; stock grazing; and planting of vegetation for conservation and recreational purposes. Obviously, conflicts can eventuate between these uses. For example, conflictions may arise between the maintenance of roadside vegetation for traffic safety considerations and indigenous vegetation conservation, with traffic safety normally taking precedence (Dawson and van der Breggen, 1991). Additionally, conflicts of interests are possible between vegetation for conservation and other uses such as: stock grazing, firewood collection and the removal of road reserve soil. Therefore, to design roads as greenways, both transportational and non-transportational uses need to be considered together at the design stage, so that the non-transportational uses [such as vegetation for conservation] are not compromised. This necessitates coordination between wildlife managers, road management authorities, local government, utilities, landowners and others who have interests in roadside management (Bennett, 1991).

HOW IS THE LANDSCAPE AND ROAD NETWORK MANAGED IN NEW ZEALAND?

The above section identifies gaps in the conservation and management of New Zealand's resources. Figure 3.1 provides an illustration of the landscape management regime in New Zealand. Apart from private landowners, DoC and local authorities [regional, district and city councils] are responsible for landscape management. Appendix 1.2 introduces the Resource Management Act 1991 [RM Act] and discusses how the Act deals with the term "landscape". The Conservation Act 1987 and DoC's role in landscape management is also outlined in Appendix 1.2. While

Figure 3.1 Integrated Landscape Management in New Zealand
(Adapted from: DoC, 1993b)



DoC is primarily concerned with conservation land, the Department still has an important role to play in integrating conservation values with the road network through it's advocacy role for species in general. However, whether or not this opportunity is fulfilled may depend on the degree to which funding is provided to DoC by the New Zealand Government.

Integrated landscape management between the RM Act and the statutes administered by and responsibilities of DoC is revealed in Figure 3.1. Under the Conservation Act 1987, DoC must advocate that regional and territorial authorities provide for conservation matters to be recognised in their plans. Under the RM Act, councils must also have regard to Conservation Management Strategies [CMS] in preparing their plans (DoC, 1993b). As discussed below, RM Act plans influence the management of the roading network. Therefore, the integration of conservation and roading activities is included implicitly in this management regime [Figure 3.1] through the requirement of RM Act plans to have regard to conservation matters.

The methods available under the RM Act, Conservation Act and other statutes administered by DoC for protecting patches and corridors on private and public land are outlined in Appendix 1.2. The issues associated with private property conservation [Appendix 1.1] are also related to each protection method. Although these methods are not relevant to the centre of this thesis, they impact on it as roads transverse patches and corridors which vary in terms of management regime, such as reserves and covenants. Therefore, the management regime of the adjoining land will ultimately affect three things when utilising roads as greenways. Firstly, the adjacent management regime will affect the way in which connections will be made between the roadside and surrounding landscape matrix. Secondly, the way in which conservation objectives are achieved in the landscape will be influenced by the adjacent management regime. Thirdly, the management regime which exists adjacent to the roadside will determine how we restore the landscape, and therefore conservation and restoration of the whole landscape. Thus, understanding of the methods and issues associated with nature conservation is crucial to the ultimate integration of protection methods identified in Appendix 1.2.

RESOURCE MANAGEMENT ACT 1991

Local authorities are involved in administering private land under the RM Act. The RM Act identifies functions, powers and duties of regional councils and territorial authorities. The functions of territorial authorities [district and city councils] are outlined in Section 31 of this Act. These authorities have primary responsibility for land use management, subdivision, natural hazards, hazardous substances, noise and activities on the surface of water. Territorial authorities therefore have an important responsibility for the management of land use effects on the roading network. For example, these authorities are responsible for maintaining visibility along the road corridor. Territorial authorities perform their functions through district plans [Figure A3.4], outlined in Sections 72-76 of this Act.

Section 30 of the RM Act prescribes functions for regional councils. These councils are responsible for the management of soil, water [quality and quantity], natural hazards, hazardous substances, geothermal resources, pollution control and regional land transport. Regional policy statements [RPS] provide an overview of the resource management issues in the region, and provide for the integrated management of its natural and physical resources [Sections 59-62, RM Act] (MWRC, 1995). Therefore, the RPS is a potential tool that can be used to achieve coordinated management of the roading network and patches and corridors on land adjacent to the road. Regional councils can also prepare regional plans which detail provisions relating to issues identified in the RPS, through Sections 63-70 of the RM Act (Milne, 1996).

As outlined above, the RM Act places responsibility on territorial authorities to manage the adverse effects of land use. Second Schedule of this Act requires these authorities to include in their district plans "any matter relating to the management of any actual or potential effects of any use, development, or protection on: the community or any group within the community, and natural, physical, or cultural heritage sites and values, including landscape, land forms, historic places, and waahi tapu" (Resource Management Act, 1994:355). This therefore places the onus on territorial authorities for managing any effects on the landscape.

However, a Taranaki Regional Council (1992) report concludes that regional councils are also responsible for landscape protection, because despite the limitations of Section 30 [Functions, Powers, Duties], attention can also be drawn to the Second Schedule. As in the territorial authority case, the above quoted paragraph must also be included in regional policy statements and plans. The Taranaki Regional Council report concludes that overall landscape planning, management and policy formulation is most properly a regional council responsibility.

The RM Act influences management of the roading network through the provision which prescribes local authorities with the responsibility of public utilities. Local authorities have "requiring authority" status under Section 168 of the Act which enables them to require specific pieces of land to be designated in the city or district plan for their public works. Once the land is designated for public work [such as a road], Section 176 of the RM Act enables the requiring authority to do anything that is in accordance with that designation, but other people require the consent of that authority before doing anything to the land (MDC, 1997:72). When applying for a resource consent, the applicant must prepare an Assessment of Environmental Effects [Section 88(4)b] which identifies all positive and negative effects that may arise from the activity (Dixon, 1993). This document must state how the adverse effects will be mitigated [Fourth Schedule (1)g]. Section 175 requires the designation to be treated as if it were a rule in the district plan (Resource Management Act, 1994).

There is considerable potential for the RM Act to be applied in dealing with the adverse environmental effects of new transport infrastructure [for example through the Assessment of Environmental Effects process in the Fourth Schedule]. However, the RM Act is criticised by the Ministry of Transport (1996) as being inadequate to control environmental effects from existing infrastructure, due to existing use rights. This criticism also includes the Act's ineffectiveness in dealing with non-point source pollution, including run-off from road surfaces. In a situation where pollution is derived from several unknown sources there is no one person who must apply for a resource consent, and enforcement is difficult. Thus, while the RM Act is potentially powerful for managing adverse effects, there are still pressing issues which are not addressed under this statute.

Table 3.1 outlines how greenway objectives can contribute to achieving the RM Act's purpose and associated principles in Part II of the Act. Most greenway objectives involve the "protection", "management" or "enhancement" of each issue. The objective relating to natural hazards requires "mitigation". The greenway objective of "education" incorporates scientific interpretation, as well as the teaching of natural and cultural issues to the public. "Expression" includes personal, patriotic, commemorative, cultural, and socio-political forms of expression (Bischoff, 1995). Table 3.1 reveals that although each greenway objective can be used to attain at least some RM Act principles, there are still many areas which are not addressed comprehensively by this Act. For example, the greenway domains of recreation, culture, history, expression, and public safety are addressed by only a few of the RM Act principles, therefore limiting their management under this Act. Amenity, followed

RM Act 1991 Objectives	Greenway Planning Objectives											
	Biodiversity	Water	Natural Hazards	Recreation	Culture	History	Public Access	Education	Expression	Development Control	Amenity	Public Safety
S 5(1)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
S 5(2)(a)	Yes	Yes	~	Yes	Yes	Yes	No	~	~	Yes	Yes	~
S 5(2)(b)	Yes	Yes	Yes	No	No	No	No	Yes	No	Yes	Yes	No
S 5(2)(c)	~	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
S 6(a)	Yes	Yes	Yes	No	Yes	Yes	No	Yes	No	Yes	Yes	No
S 6(b)	Yes	Yes	Yes	No	No	~	No	~	No	Yes	Yes	No
S 6(c)	Yes	Yes	Yes	No	No	No	No	~	No	Yes	Yes	No
S 6(d)	No	~	Yes	Yes	No	No	Yes	No	No	No	Yes	Yes
S 6(e)	~	Yes	No	No	Yes	Yes	No	Yes	Yes	Yes	Yes	No
S 7(a)	No	No	No	No	Yes	Yes	No	~	Yes	No	~	No
S 7(b)	~	Yes	Yes	No	No	No	No	~	No	Yes	~	No
S 7(c)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
S 7(d)	Yes	Yes	~	No	No	No	No	No	No	No	~	No
S 7(e)	Yes	Yes	~	No	Yes	Yes	~	Yes	Yes	~	Yes	No
S 7(f)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	~	~	Yes	Yes	Yes
S 7(g)	Yes	Yes	Yes	No	No	Yes	No	Yes	Yes	Yes	~	No
S 7(h)	Yes	Yes	No	Yes	No	No	No	No	No	~	Yes	No
S 8	No	No	No	No	Yes	Yes	No	Yes	Yes	No	Yes	No

Table 3.1 Potential for Greenway Objectives to Achieve RM Act Principles

Legend:		
	Yes	Strong Relationship
	~	Slight Relationship
	No	No Relationship

by water and biodiversity, are the only objectives which are extensively addressed by RM Act principles, and therefore could be managed under this Act.

LOCAL GOVERNMENT ACT 1990

The Local Government Act 1990 [LG Act] provides important guidelines for managing New Zealand's roading network. Appendix 2 provides the definition of "road" contained in the LG Act. This definition includes: "every square or place intended for use of the public generally...[Section 315]". Therefore, the road can be viewed as the area between the boundary fences on both sides of the carriageway, including the road verge. The same definition is used in the Transit New Zealand Act 1989, and in *Highway Planning Under the Resource Management Act 1991* [discussed below] which requires territorial authorities to use this definition (Transit New Zealand, 1994).

Sections 37S and 37T of the LG Act set out the general functions, duties and powers of regional councils and territorial authorities, respectively. These include performing the functions, duties and powers conferred on local authorities by this Act and any other act applicable. Section 317 of the LG Act prescribes the control of all roads, other than state highways, government roads and regional roads, to territorial authorities. However, the management of state highways and regional roads may be delegated to territorial authorities: under Section 62 of the Transit New Zealand Act 1989 by Transit New Zealand for state highways, and under Section 368 of the LG Act by regional councils for regional roads. Section 319 of the LG Act prescribes the powers territorial authorities have in respect of roads. These include: to lay out new roads; to divert or alter the course of any road; to change the width of any road; determining the carriageway, footpath or cycle track; to alter the level of any road. The Eleventh Schedule of this Act also provides guidelines in respect of road width. Every road should not be less than 20 metres wide, but where it is not appropriate for 20 metres along all of its length, the road may be a width of not less than 12 metres.

TRANSIT NEW ZEALAND ACT 1989

The Transit New Zealand Act 1989 [TNZ Act] is an important statute for the management of the roading network. The TNZ Act defines the hierarchy of the main organisations involved in management of the land transport system. Figure 3.2 illustrates the responsibilities of territorial authorities, regional councils and central government [Transit New Zealand, Ministry of Transport] in land transport management.

The primary role of territorial authorities under the TNZ Act is to prepare a District Land Transport Programme for its area [Section 24]. This programme must set out all projects planned for the following year for which funding is sought from the Land Transport Fund (Halcrow Fox and Associates, 1993). As mentioned above, territorial authorities may also request Transit New Zealand to delegate powers for the responsibility of state highways to themselves (Ibid).

Section 25 of the TNZ Act prescribes regional councils to develop a Regional Land Transport Programme [which deals mostly with public passenger transport needs], and annual road safety reports for the region (Ibid). Additionally, regional councils must prepare a Regional Land Transport Strategy (Ministry of Transport, 1996). These strategies play a key role in planning and funding land transport development in New Zealand. While formulating these strategies, regional councils must have regard to the effects that transport systems are likely to have on the environment. The strategies must not be inconsistent with plans produced under the RM Act (Ibid).

The Crown entity of Transit New Zealand was created from a merger between the former National Roads Board and Urban Transport Council in 1989 (Transit New Zealand, no date). The objective of Transit New Zealand is "to promote policies and allocate resources to achieve a safe and efficient land transport system that maximises national economic and social benefits" (Transit New Zealand, 1994). As can be seen from this objective, environmental concerns are excluded. This exclusion may be crucial when designing future roads as greenways in New Zealand.

As Figure 3.2 shows, Transit New Zealand is primarily responsible for the preparation of a National Land Transport Programme which is developed out of the Regional Land Transport Programmes [Section 6, TNZ Act]. The authority is also responsible for: providing recommendations to government on the income and expenditure levels from the Land Transport Fund; funding and auditing approved projects; management of the State Highway system; providing assistance and advice to local authorities regarding their functions, duties and powers under the TNZ Act; and providing research and information on land transport systems [Section 6, TNZ Act] (Halcrow

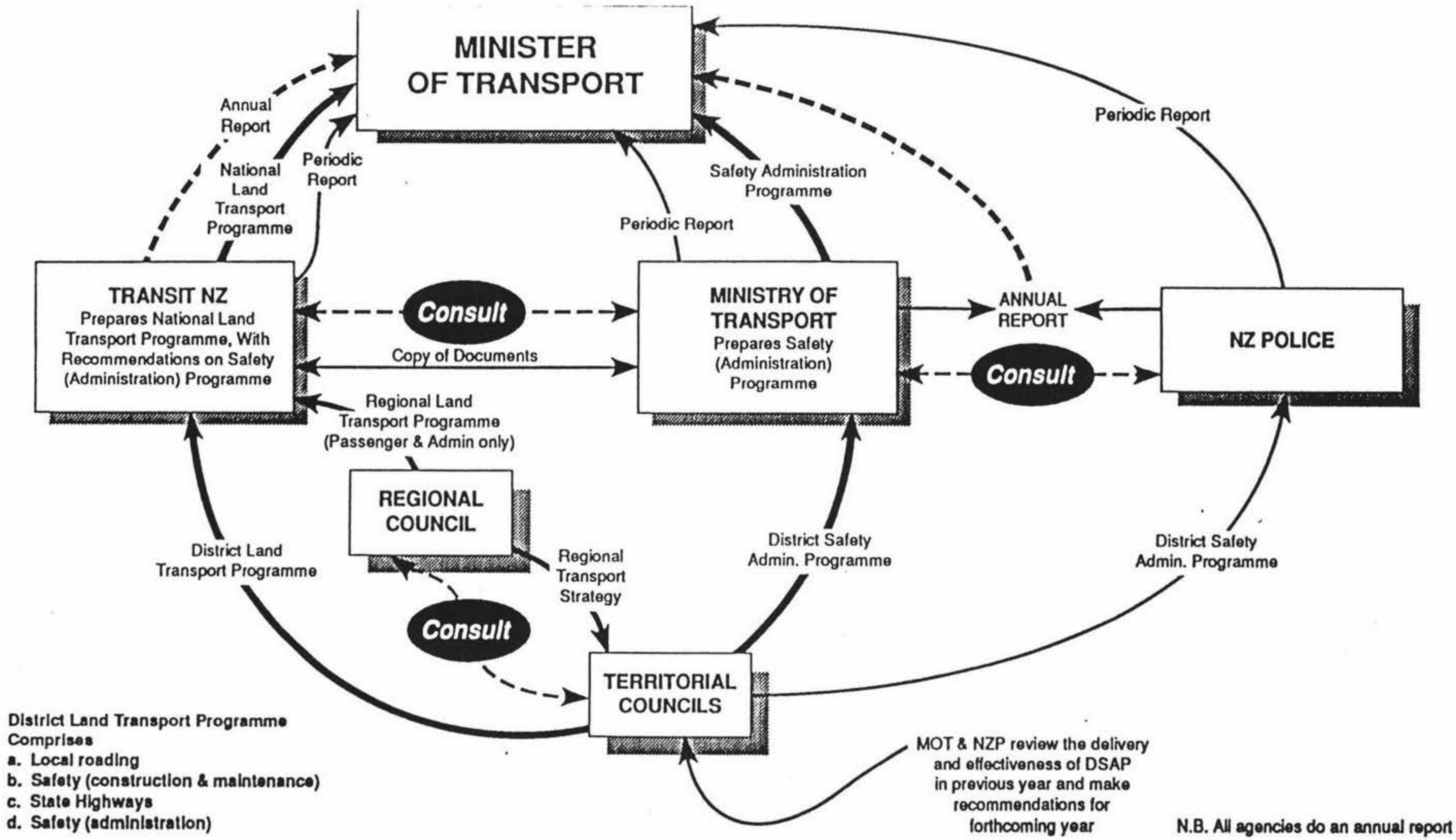


Figure 3.2 Planning Relationships of the Organisations Administering the Land Transport System in New Zealand, Under the Transit New Zealand Act 1989 (Halcrow Fox and Associates, 1993:21)

Fox and Associates, 1993). Once developed, the National Land Transport Programme is sent to the Minister of Transport for consideration and approval. The Ministry of Transport has overall responsibility for road traffic safety, complementing the role of New Zealand Police (Ibid). However, the road traffic safety aspect of land transport will not be discussed further in this thesis.

As outlined in Appendix 1.2, the RM Act's definition of "natural and physical resources" includes the word *structure*. This is defined as:

> "any building, equipment, device, or other facility made by people and which is fixed to land" (Resource Management Act, 1995: 20).

Transit New Zealand interprets this definition to include the roading network. Hence part of the RM Act's purpose is to promote the sustainable management of the roading network (Transit New Zealand, 1994). There are two converse perspectives in regard to this issue. First: the effects of the roading network on the environment, and second: the effects of land use on the roading network. Transit New Zealand has developed two documents to address both perspectives. The first perspective is addressed through Transit New Zealand's environmental strategy in *Transit New Zealand and the Environment*. Through this document, Transit New Zealand aims to reduce and, where possible, avoid the adverse environmental effects from the road network and improve the natural, physical and social environments (Transit New Zealand, no date).

Highway Planning Under the Resource Management Act 1991 is concerned with the conservation and improvement to New Zealand's roading network through the avoidance or mitigation of the adverse effects of land use activities. This document focuses on the second perspective. As identified earlier, the RM Act requires territorial authorities to be primarily responsible for the management of land use effects on the roading network. This document provides territorial authorities with guidance on how to achieve a safe and efficient roading network through their district plans (Transit New Zealand, 1994). For instance, Transit New Zealand suggests that all territorial authorities adopt a roading hierarchy where roads are classified by the predominant function they carry out. The highest classified roads are "arterials" providing minimum access but high through movement, while at the lower end of the scale, "local streets" provide a major access function and little through movement. Table 3.2 identifies the roading hierarchy suggested by Transit New Zealand, which if adopted by all territorial authorities, ensures a unified approach to road management (Transit New Zealand, 1994).

Table 3.2 Recommended Roading Hierarchy by Transit New Zealand (Adapted From: Transit New Zealand, 1994:21)

Category	Description	Roads Included
National Routes	Roads which: - form part of a network of strategic importance, and - are a significant element in the national economy	- motorways, and - principal state highways
Primary/Regional Arterials	Roads which are: - of strategic regional importance, and - a significant elements in the regional economy	-state highways not included in National Routes category, - roads giving access to important tourist areas or significant areas of population; - roads linking different transport modes; - roads providing significant intra-urban links, and - all other roads of regional or inter-regional importance
Secondary/District Arterials	Roads which are: - of strategic district importance, and - a significant element in the local economy	- links between residential, commercial, industrial or recreational land use activities
Collector Routes	Routes which are: - locally preferred between or within areas of population or activities, -complementary arterials, and - usually paved and are of road geometry aligned with operational safety standards required for the traffic volumes on each section	- primarily suited to urban situations, yet have a place in rural areas. In rural areas, where land use activity is relatively intensive, it is necessary to provide links between local roads and arterials
Local roads	Roads whose primary function is property access	All other roads servicing land use activity

Highway Planning Under the Resource Management Act 1991 also provides guidance to territorial authorities on provisions for property accesses, intersections, vehicles and vegetation in relation to state highways. Territorial authorities must ensure that all accesses to state highways are located, designed and constructed so that vehicles can enter and leave a site at all times safely and conveniently, and without causing any adverse effects on the safe and efficient operation of the state highway as a through route (Ibid, 1994:65). Therefore, the location of property accesses should ensure that: minimum spacings between accesses or between accesses and intersections are achieved, and adequate sight distance for all vehicle movements is provided (Ibid, 1994:69). These controls are outlined in Figure 3.3. However, the safety parameters of property access are not analysed in this thesis as the topographic

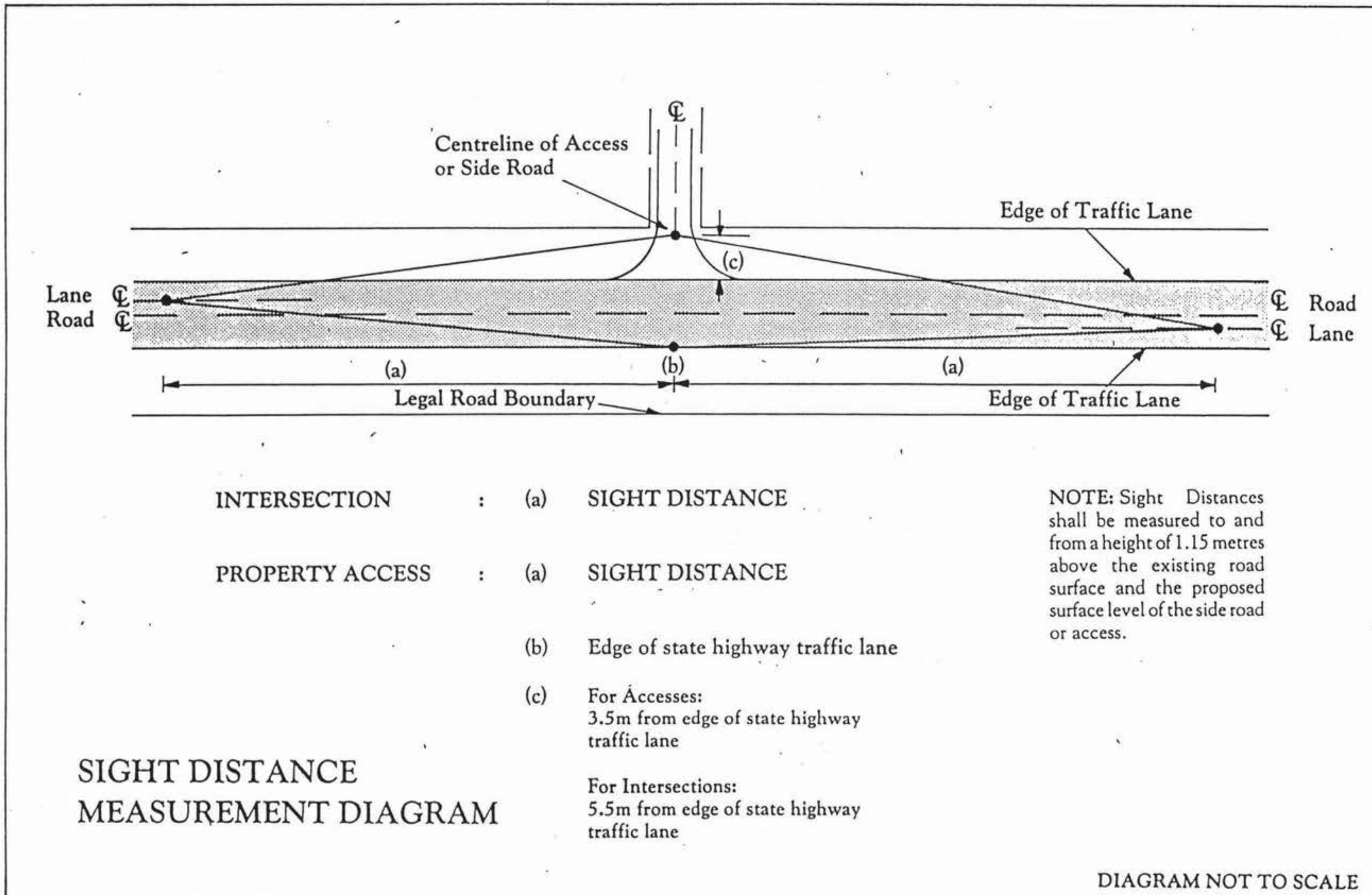


Figure 3.3 Sight Distance Measurement Diagram (Source: Transit New Zealand, 1994:68)

maps used in Chapter Five do not clearly indicate where each property access is located.

Transit New Zealand requires territorial authorities to control vegetation so that visibility at road intersections and property accesses is optimised, and that the occurrence of road icing caused by vegetation shading is minimised (Transit New Zealand, 1994:77). Territorial authorities must ensure that intersections with state highways are designed and located appropriately to ensure adequate spacing so as not to adversely affect the free flow of traffic on the state highway (Ibid, 1994). Territorial authorities must also make sure that adequate sight distance is available for all vehicle movements from intersections (Ibid). These controls are outlined in Table 3.3 and Figure 3.3. The guidelines should also be used for intersections which are formed by a state highway and a local road on which a railway crossing is located.

Table 3.3 Recommended Minimum Sight Distance From Intersections By Transit New Zealand (Adapted from: Transit New Zealand, 1994:67)

Speed (km per hour)	Optimum Sight Distance (metres)	Minimum Sight Distance (metres)
50	125	80
60	160	105
70	220	130
80	305	175
90	400	210
100	500	250
110	500	290
120	500	330

However, in order to provide a safe and efficient roading network, agencies involved in the design and management of roads must also consider basic elements and principles of road design. These elements may inevitably influence the future use of roads as greenways. The factors which must be considered in road design are discussed below.

FACTORS TO BE CONSIDERED IN ROAD DESIGN

An important objective in the design of roads is to reduce the number and severity of road accidents while ensuring high traffic capacity with the minimum of delay to vehicles. Therefore, road safety is a major consideration in road design. Geometric design is concerned with relating the physical elements of the road to the requirements of the driver and the vehicle. The proper geometric design of roads will inevitably reduce the number and severity of road accidents while ensuring high traffic capacity with the minimum of delay to vehicles. The features of geometric design which must be considered include: horizontal and vertical curvature; the cross-section elements; and the lay out of intersections (O'Flaherty, 1975). Each of these elements must be designed so that the minimum sight distance is not adversely affected. The design speed of roads is also influential on road geometry. Appendix 3 introduces each of these features and discusses their importance in the geometric design of roads.

The only New Zealand design standards available for analysing how road design influences the use of roads as greenways relate to the minimum sight distances at intersections. Therefore, implications of the design features outlined in Appendix 3 will not be considered further in this thesis, however, it is recognised that they will still play an important role in influencing road design, and hence the future use of roads as greenways.

However, considerations in road design must not only relate to safety, capacity and efficiency concerns. Although not as important as road design geometry, regard should also be given to providing an aesthetically pleasing picture to both the driver and passenger (O'Flaherty, 1975). Appendix 3 outlines design techniques which enable the road to be integrated with the surrounding landscape so to provide an aesthetically pleasing landscape. Keeping in mind the overriding importance of safety in road design, a potential opportunity for future greenway initiators is to utilise roadside planting to enhance road safety. Techniques for achieving road safety through planting are also listed in Appendix 3. Therefore, when designing roads as greenways, several important factors have to be considered in road design. Some of these factors may inevitably influence the effectiveness of the greenway.

CONCLUSIONS

This chapter has identified the need for an integrated approach to the conservation of patches and corridors into local land use patterns. An enormous opportunity is provided for this by the utilisation of future roads as greenways. As this chapter identifies, several agencies are involved in the management of the roading network and adjacent landscape in New Zealand. Additionally, conflicts may arise between the various activities which occur in the road reserve. The use of roads as greenways would therefore require extensive coordination between DoC, local authorities, Transit New Zealand, landowners and utility managers throughout design, construction and management phases of roads.

The present management regime could attain the coordination required in theory between public roads and the adjacent landscape through two main areas. Firstly, despite the RM Act's limited involvement in the roading network, regional policy statements prepared under this statute are a potentially powerful tool for coordinating management between agencies involved in road design and management, namely territorial authorities and Transit New Zealand. Secondly, DoC's advocacy role could play an important part in requiring integrated management of patches on conservation land and roadside verges.

The LG Act is an important statute in roading management as it prescribes the control of local roads to territorial authorities. The Act also contains provisions regarding the width of roads, and provides a universal definition of "road". The use of roads as greenways, however, may be hindered in the approach defined by Transit New Zealand's objective where environmental concerns are ignored. This is important since Transit New Zealand controls state highways and guides territorial authorities in how they should manage local roads. Geometric design elements may also provide impediments to achieving the integration of roadsides and conservation. The major concern in this respect tends to be safety, and in particular, visibility. Safety requirements cannot be ignored as the overriding purpose of a road is to provide [safe] transportation. However, the use of planting to enhance road safety is a potential opportunity in which future greenway planners can achieve both ecological and safety objectives in road design. In addition, road design principles which require the integration of the road and surrounding landscape, can also be used to achieve greenway objectives in road design.

The road design and safety considerations discussed in this chapter and Appendix 3 will be applied to each case study in Chapter Five to determine their influence in using roads as greenways. The next chapter will analyse the management regime for each of the case study roads. The case studies will be analysed according to three criteria regarding the ability of the relevant agencies to manage roads as greenways.

CHAPTER FOUR

CASE STUDY ROADS

This chapter introduces the case studies used in this thesis to illustrate the extent of coordination between the agencies involved in landscape and road management. The degree of support in policy documentation for greenway initiatives is also analysed. This will identify the impediments and opportunities of the present management regime in utilising roads as greenways in New Zealand. First, the basic characteristics of each site are outlined, which complements the introductory information provided on each case study in Chapter One. The management regime of the case studies is then analysed. Objectives, policies and methods of relevant agencies will be analysed according to three criteria to ascertain the extent of policy coordination between each agency. This chapter also relates the characteristics of the case studies back to the greenway characteristics identified in Chapter Two. Where appropriate, State Highway 54 and Pohangina Valley East Road are discussed together because both are managed by the same local authorities, and in some cases exhibit similar landscape characteristics.

CHARACTERISTICS OF EACH ROAD

An important greenway characteristic identified in Table 2.3 is the tendency for greenways to follow the topographic logic of a place. That is, greenways are often based on natural landscape features, such as ridgelines or rivers (Hoover and Shannon, 1995; Little, 1990). The case study roads applied in this thesis use the road as the core element in the greenway. Hence, the greenway may or may not follow the topographic logic of the landscape. For instance, the Pohangina Valley East Road does follow the Pohangina River and its valley. On the other hand, the proposed Sandhills route and State Highway 54 cut across the natural contour of the surrounding landscapes. However, by using the road as the central greenway element in each case study, the general greenway characteristics of length and linearity are exhibited. The landscape adjoining the roads in each case study is a mixture of private, leasehold or public ownership. This mixture of property ownership is also characteristic of greenways in theory.

According to Thorne (1993:37), the siting of a greenway requires an application of "contextualism". This entails examining the context within which the proposed greenway will exist. Two aspects of landscape structure are important in this respect: the pattern of elements in the landscape and the trends of the surrounding landscape matrix. The first aspect will be covered in Chapter Five, while the second aspect is discussed in relation to each case study throughout this chapter.

As discussed in Chapter One, the three case study roads are located in the lower North Island of New Zealand [Map 1, Chapter One]. These roads transverse highly modified landscapes where the remaining patches and corridors of indigenous vegetation and wetlands are generally small in size. The characteristics of each landscape are outlined in greater detail below.

Figure 4.1 provides an aerial plan and approximate length of each case study road. As shown in Figure 4.1A, the State Highway 54 route is characterised by steep gradients and tight corners, with few flat stretches of road in between. This places constraints on the speed of vehicles, though the maximum speed limit of 100 kilometres still applies. Figure 4.1B shows that the Pohangina Valley East Road is relatively straight, with only a few tight bends and steep gradients. The speed limit for this road is also 100 kilometres per hour. Figure 4.1C identifies the straighter route taken by the Sandhills Bypass as compared to the first two case study roads. The proposed speed limits along the Sandhills Bypass range from 50 to 100 kilometres per hour [refer to Table 5.3C]. Figure 4.1 will be discussed throughout this thesis as either Figure 4.1A, 4.1B or 4.1C as it relates to each case study.

Both State Highway 54 and the Pohangina Valley East Road run through a landscape matrix dominated by agriculture. The Sandhills Bypass cuts across a landscape that is peri-urban and rural. As outlined in Chapter Two, the surrounding matrix exerts the most control over landscape processes and change. An agricultural landscape matrix typically has relatively slow rates of land use change, and higher rates of nutrient and material fluxes. For instance, runoff from agricultural land use transports sediment, nitrates, phosphates and pesticides to the riparian environment, reducing water quality and altering stream structure through increased sediment loads (Ahern, 1995:135). Rural landscapes generally experience change in a discontinuous manner, where pockets of change may occur, but may not be connected. This is characteristic of the landscapes surrounding State Highway 54 and Pohangina Valley East Road.

Figure 4.1 Aerial Plan and Length of Case Study Roads

Figure 4.1A State Highway 54 (approximate length 15 km)

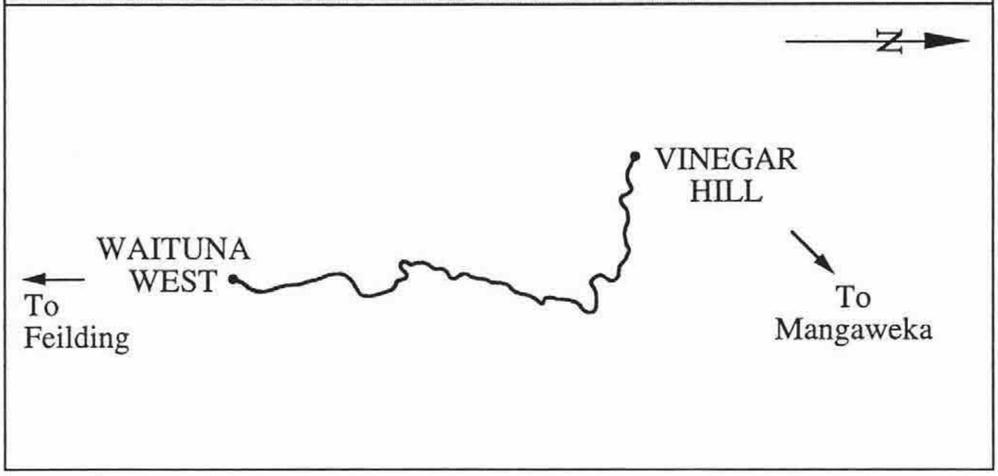


Figure 4.1B Pohangina Valley East Road (approximate length 13 km)

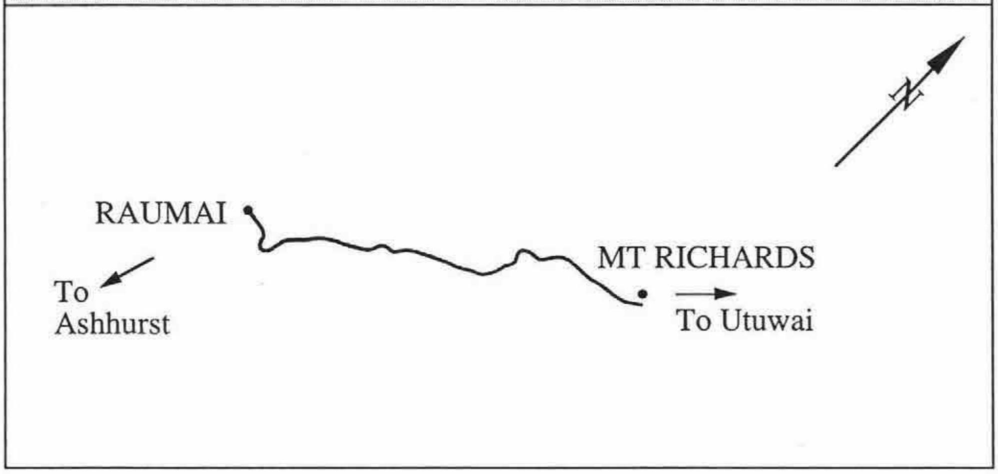
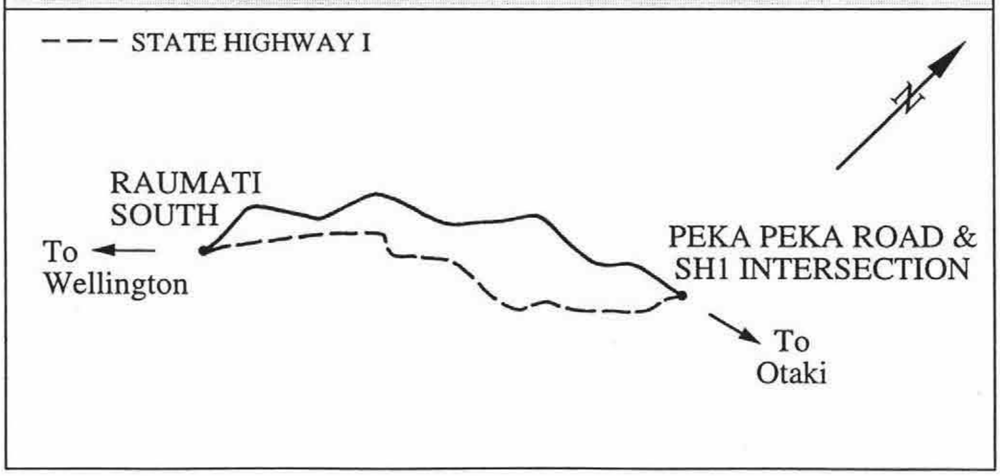


Figure 4.1C Proposed Sandhills Route (approximate length 15 km)



Urban-rural landscapes also have high rates of nutrient and material fluxes. For example, increased volumes of stormwater runoff alters the hydrological characteristics of riparian systems. However, urban-rural landscape contexts experience continuous land use changes, such as the subdivision of previously rural or near natural areas (Ibid, 1995). In this type of landscape, change initially takes place discontinuously, but as the changes intensify [for example, when subdivision increases enough to create a settlement], the pockets of change may integrate so that the resulting landscape is peri-urban, evolving into an urban matrix. The landscape surrounding the Sandhills Bypass route is characteristic of these landscape processes.

DoC (1997) describes the landscape of the Manawatu Plains Ecological District which contains State Highway 54 and Pohangina Valley East Road, as once being dominated by native forest, which is now overwhelmed by human elements, including land which is intensively farmed. The landscape is both separated and connected by a dense pattern of roads, hedges and fences. The original forest has been reduced to small patches [particularly in the State Highway 54 case study], which are typically squared off to conform to the boundaries of properties and paddocks. An important remaining landscape element is secondary forest along the steep faces of river terraces. These thin corridors of forest are often interrupted by property boundaries or farming practices (Ibid).

The landscape surrounding the Sandhills Bypass case study is characterised by many important remnants of coastal dune wetlands, coastal forests, and shrublands, river and stream margins and estuaries (DoC, 1996; Opus International Consultants, 1997a). The landscape is a substantially modified environment. As shown in Figure 4.2, prior to European occupation the coastal plain west of State Highway One was dominated by "The Great Swamp" (KCDC, 1993a). However, much of the original wetlands have been drained and cannalised to carry runoff from surrounding farmland, resulting in less than 10 per cent of the original wetlands remaining (KCDC, 1993a; Opus International Consultants, 1997a).

CASE STUDY ONE: STATE HIGHWAY 54

As discussed in Chapter One, Case Study One involves the northern part of State Highway 54 [Map 1, Chapter One; Figure 4.1(A)]. As the views are *out and over* from the road [Figure 1.3A], implications for applying the greenway concept emanate as it may be difficult to include part of the subject landscape [vista] into the greenway network. Additionally, since views are important in this case study [Stormy Point,

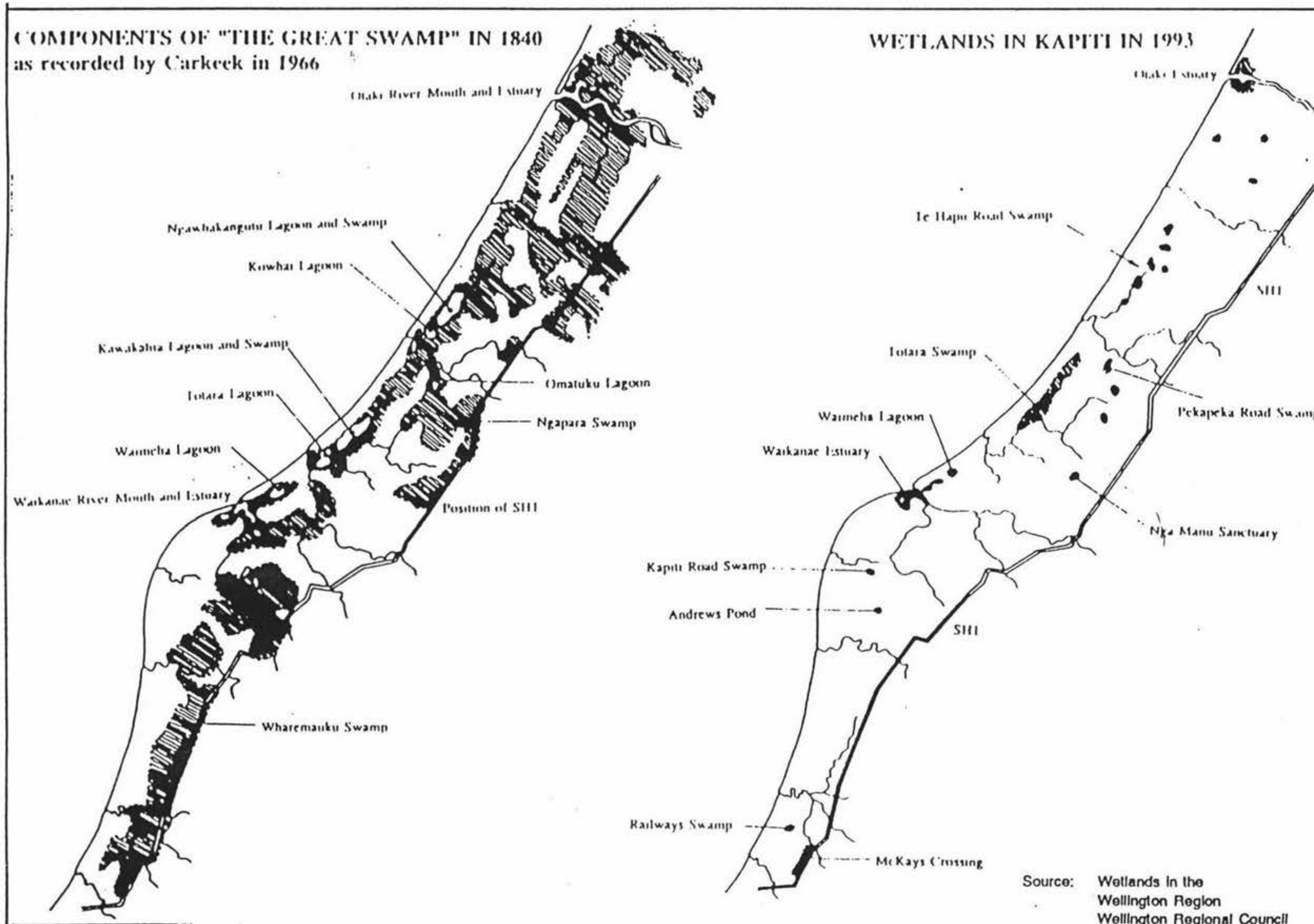


Figure 4.2 The Original Network of "The Great Swamp" in 1840 and the Remaining Wetlands in 1993 (KCDC, 1993a:6)

Map 5.3A, Appendix 4] protection of outlook may potentially conflict with enhancement of corridors between patches within or beside the greenway.

Sheep and cattle farming and exotic forestry dominate the landscape surrounding State Highway 54. Many of the existing patches and corridors are widely spaced and unconnected due to the intensive land use in this case study. The area is characterised by a number of small stream corridors which feed into the Rangitikei River. The river runs perpendicular to State Highway 54, crossing over the road at the Vinegar Hill Domain. The Rangitikei River and associated streams provide a basis for potential landscape linkages with State Highway 54.

CASE STUDY TWO: POHANGINA VALLEY EAST ROAD

Figure 4.1B outlines the study reach of Case Study Two: the Pohangina Valley East Road. Since the road is located *in* the subject landscape [Figure 1.3B], the inclusion of significant landscape elements into the greenway network is possible. The importance of views along this road [discussed in Chapter One] raises the issue of potential conflict between protection of the outlook and enhancement of the corridors between patches within or beside the greenway.

Pohangina Valley East Road is surrounded by cattle and sheep farming, dairying and some exotic forestry on the steeper land. The area differs substantially from State Highway 54 in that there are some large patches of indigenous lowland vegetation interspersed with farmland. Although Totara Reserve constitutes much of this vegetation, there are still several smaller remnant patches and corridors of bush and scrub located close to the road. These patches and corridors are better connected than those in the State Highway 54 case study. As with the Rangitikei River in Case Study One, the Pohangina River provides an important basis for linkage between landscape patches in this case study.

CASE STUDY THREE: SANDHILLS BYPASS

Case Study Three entails the proposed Sandhills Bypass designation in the Kapiti Coast District Plan between Peka Peka Road and south of Poplar Avenue. The route is shown on Map 2 [Chapter One] and Figure 4.1C. As discussed earlier, the environment surrounding the proposed Sandhills route is a mixture of urban and rural land uses. The major settlements are: Raumati, Paraparaumu, and Waikanae. The rural landscape supports mostly sheep and cattle grazing. The area through which the proposed route travels is under significant development pressure due to the high population growth rates which characterise the Kapiti Coast District (KCDC, 1993c).

Views are not significant in this case study. Therefore, the issue of conflict between outlook protection and enhancement of corridors between patches beside or within the greenway is not important. Since the proposed route is located within the landscape [Figure 1.3C], this enables valuable landscape elements to be easily incorporated into a potential greenway network.

The basic design parameters of the Sandhills road will include shoulders throughout the road, and a median strip to separate opposing traffic flows, which may also be used as a planting strip [refer to Appendix 3 for discussion of shoulders and medians]. Table 4.1 outlines the number of lanes proposed along the Sandhills Route. The total width of the Kapiti Coast District Plan designation for the Sandhills route is 100 metres. The overall road formation width for a four laned road is 42 metres [unkerbed] and 30 metres [kerbed]. For a two laned road, the formation width is 26 metres [unkerbed]. These widths do not include items such as: the cut and fill batters and drainage ditches (Opus International Consultants, 1997a).

Table 4.1 Number of Lanes Proposed for the Sandhills Bypass (Opus International Consultants, 1997a)

Section	Initial Lane Number	Ultimate Lane Number
Poplar Ave to Raumati Road	2	2
Raumati Road to Mazengarb Road	4	4
Mazengarb Road to Waikanae River	2	4
Waikanae River to Te Moana Road	2	4
Te Moana Road to SH 1	2	2

As detailed earlier this chapter, Case Study Three focuses on wetland patches and corridors, as compared to the previous two case studies where vegetation patches and corridors are important. While vegetation patches and corridors are probably the most common type used for achieving a connected landscape, they do not need to be the dominant factor in defining landscape management objectives. Hydrologic factors significantly determine the physical and biotic features of riparian ecosystems, and also perform corridor functions directly through the linear movement of water. Hence, the characteristics of riparian vegetation corridors reflect the dominant hydrologic processes (Cross, et al. 1991). The restoration emphasis in Case Study Three focuses on using the Sandhills Bypass as a greenway to enhance the connectivity between wetland patches and corridors, with the possibility of restoring the original network of The Great Swamp outlined in Figure 4.2.

MANAGEMENT REGIME OF CASE STUDY ROADS AND SURROUNDING LANDSCAPES

POLICY COORDINATION REQUIREMENTS

As identified in Chapter Two, the linear nature and length of greenways means that they often transverse jurisdictional boundaries. If no attempts are made to coordinate policies, degradation or even loss of the greenway and its dependent resources is possible (Hoover and Shannon, 1995). Table 4.2 outlines the primary agencies and relevant documents involved in management of the landscape and roads within each case study. As shown on Table 4.2, State Highway 54 crosses the jurisdictional boundary of Manawatu District Council [MDC] and Rangitikei District Council [RDC]. This boundary is defined by the Rangitikei River, hence the study reach of State Highway 54 and its surrounding landscape is managed dominantly by MDC. However, part of the landscape which constitutes views from State Highway 54 is managed by RDC. This road is also transected by the Manawatu Plains and Rangitikei Ecological Districts which are administered by DoC. Policy coordination between authorities, particularly between relevant district councils, is therefore essential if the road is to be managed as a greenway.

The Pohangina Valley East Road is contained within the MDC jurisdictional boundary [Table 4.2]. However, the Pohangina River defines the boundary between the Wanganui and Hawkes Bay Conservancies. Therefore, all protected areas within the landscape surrounding Pohangina Valley East Road are managed under either the Wanganui or Hawkes Bay Conservation Management Strategies [CMS]. Both State Highway 54 and Pohangina Valley East Road are managed by the Manawatu-Wanganui Regional Council [MWRC].

The Sandhills Bypass route does not transverse jurisdictional boundaries. As shown in Table 4.2, the landscape in which the route is located is managed solely by the Kapiti Coast District Council [KCDC], the Wellington Regional Council [WRC], and is under jurisdiction of the Wellington CMS. Although coordination is essential between spatially adjacent agencies, policies for greenways must also be coordinated between the different levels and types of government, for instance between territorial authorities, regional councils, DoC and Transit New Zealand [refer to Chapters Two and Three for further discussion on policy coordination for greenways].

Table 4.2 Agencies and Associated Documents Involved in Management of Case Study Roads and Landscapes

Agency	State Highway 54 [SH54]	Pohangina Valley East Road	Sandhills Bypass Route
Territorial Authority	Manawatu District Council [District Plan] Rangitikei District Council [District Plan; Reserves Management Strategy] District Land Transport Programmes	Manawatu District Council [District Plan; District Land Transport Programme]	Kapiti Coast District Council [District Plan; District Land Transport Programme]
Regional Council	Manawatu Wanganui Regional Council [Regional Policy Statement; Regional Land Transport Strategy]	Manawatu Wanganui Regional Council [Regional Policy Statement; Regional Land Transport Strategy; Manawatu Catchment Water Quality Regional Plan]	Wellington Regional Council [Regional Policy Statement; Regional Land Transport Strategy; Regional Freshwater Plan; Regional Landscape Plan]
Transit New Zealand	Manages SH 54 [financial responsibility]; provides guidelines to Manawatu and Rangitikei District Councils on management of local roads which join SH 54 through "Highway Planning Under the RM Act"	Provide guidelines to Manawatu District Council on management of roads through "Highway Planning Under RM Act"	Designated as State Highway in District Plan; Has financial responsibility for road
Department of Conservation	Wanganui Conservation Management Strategy; Protected Natural Areas Programme: Rangitikei and Manawatu Plains Ecological Districts	Wanganui and Hawkes Bay Conservation Management Strategies; Protected Natural Areas Programme: Manawatu Plains Ecological Districts	Wellington Conservation Management Strategy; Protected Natural Areas Programme: Foxton Ecological District

Chapter Three contains a discussion on the agencies involved in road management in New Zealand. Transit New Zealand controls and manages the state highway network, while territorial authorities control and manage the local roading network, unless Transit New Zealand delegates responsibility of a state highway to territorial authorities. As Table 4.2 shows, State Highway 54 is controlled and managed by Transit New Zealand. Since the Pohangina Valley East Road is not a state highway, the relevant territorial authority [MDC] controls and manages this road. However, Transit New Zealand is also involved in the management of Pohangina Valley East

Road by providing guidelines to the MDC on how to achieve a safe and efficient roading network in general. These guidelines should be included in the district plan (Transit New Zealand, 1994). The Sandhills Bypass has been designated as a state highway in the Kapiti Coast District Plan by request of Transit New Zealand (KCDC, 1995). However, KCDC and Transit New Zealand are also investigating the possibility of using the Sandhills designation as a urban arterial [for definition of "arterial" see Table 3.2] rather than a state highway.

The MDC is preparing a section on the "Special Landscape provisions for the Pohangina Valley", for inclusion into the Manawatu District Plan. However, these provisions are still being written and have not been included in the current Manawatu District Plan. Therefore, analysis in this thesis excludes these provisions.

CRITERIA FOR ANALYSING POLICY COORDINATION AND GREENWAY SUPPORT

The importance of coordination between agencies in greenway management has been outlined above and in Chapters Two and Three. In order to assess the degree of institutional support for utilising roads as greenways in New Zealand, this section will analyse the extent of policy coordination between the agencies identified in Table 4.2. The analysis also examines the degree to which greenway initiatives are supported in policy documentation. Three criteria are used to perform this analysis. These are outlined in Figure 4.3. These criteria have been derived from theory based in previous chapters.

The first criterion analyses road design [Figure 4.3]. Three aspects are analysed in this criterion. The importance of coordination between agencies in greenway planning has been outlined. Therefore, the first part of the criterion measures the degree to which agencies coordinate policies relating to road design and management [Part A]. Chapter Three contains a discussion on the importance of incorporating non-transportational uses as well as transportational uses in road design. Part B investigates whether these agencies have incorporated greenway concepts in road design. That is, whether the agencies recognise that the road can be used for purposes other than transport. As discussed in Chapter Three, the use of roads as greenways may be impeded by the overriding requirement of safety. Therefore, Part C examines the impediments in relation to road safety requirements when utilising the case study roads as potential greenways.

Figure 4.3 Criteria for Analysing the Extent of Policy Coordination Between Agencies and the Degree of Support for Greenway Initiatives

POLICY COORDINATION AND EXTENT OF SUPPORT FOR GREENWAY INITIATIVES BY AGENCIES INVOLVED IN MANAGEMENT OF CASE STUDIES

Road Design Criterion

A. Coordination between agencies involved in road design and management
B. Whether agencies have incorporated greenway concepts in road design
C. Impediments from road safety to using road as greenway

Biodiversity Criterion

A. Focus and coordination of biodiversity protection
B. Identification of patches and understanding of management required
C. Extent to which greenway objectives are recognised in the protection of patches and corridors

Scenic Outlook Criterion

Coordination between agencies in the management of scenic outlook

Chapter Two contains a discussion on how a connected system of patches and corridors [such as greenways] can be used to enhance biodiversity. The second criterion analyses how biodiversity is managed in the case studies [Figure 4.3]. As discussed in Chapter Two, the traditional focus of conservation programmes for biodiversity protection is criticised by landscape ecologists for not acknowledging the connectivity and movement between patches and corridors. Therefore, Part A analyses the focus of biodiversity protection and the extent of policy coordination between agencies involved in biodiversity protection in each case study management regime.

The second part of the biodiversity criterion examines the extent to which the agencies understand the management that is required in the protection of biodiversity [Part B]. Each territorial authority involved in the case studies is analysed in respect of how they manage important patches and corridors in their district. Guidelines provided by Froude (1995) are used to assess this criterion. Table 3.1 outlines the various purposes for which greenways can be used. Part C of the biodiversity criterion examines the degree to which the different greenway objectives have been acknowledged in patch and corridor protection policies. As shown on Figure 4.3, the third criterion analyses the extent of policy coordination between agencies in the management of scenic outlook. This is particularly important in Case Study One, since the views are located out and over from State Highway 54, and the landscape surrounding this road is managed by MDC, while part of the scenic landscape is managed by RDC.

Road Design Criteria

Part A: Coordination in Road Design and Management Policies

As discussed above, Part A of the road design criterion examines the extent to which territorial authorities, regional councils and Transit New Zealand coordinate policies for road design and management. As regional councils play a less significant role in managing the case study roads, they will not be considered in this section. Discussions in Chapter Three outlined the importance of consistency between plans prepared by territorial authorities and the Transit New Zealand (1994) guidelines provided in *Highway Planning Under the RM Act*.

To manage effects on the roading network, the Manawatu District Plan adopts the roading hierarchy suggested by Transit New Zealand [outlined in Chapter Three]. The RDC's District Plan also adopts a roading hierarchy, but uses different classifications. Instead of using the five road categories identified in Table 3.2, the RDC District Plan defines only four and does not distinguish between primary and secondary arterials. Additionally, the RDC District Plan adopts "strategic routes" as the highest category, which resemble a combination of "national routes" and the strategic component of "primary/regional arterial" in the Transit New Zealand hierarchy [Table 3.2]. In MDC's District Plan, the Pohangina Valley East Road is classified as a "collector route [tourist]" and State Highway 54 as a "regional arterial" [for definitions refer to Table 3.2]. However, the RDC's District Plan identifies State Highway 54 as a "strategic route", which is the highest roading category for district. Therefore, while both councils have adopted a roading hierarchy as recommended by Transit New Zealand, consistency of classification between the two councils is not provided for due to the difference in hierarchies adopted. This is important as both district councils are responsible for managing the effects of land use on State Highway 54, and by adopting different classifications for the road, different management approaches may result.

The Kapiti Coast District Plan does not adopt the suggested roading hierarchy. In fact, the only reference this plan provides regarding management of land use effects on the roading network is to "ensure that all developments provide for safe vehicular and pedestrian access and adequate carparking areas" (KCDC, 1995:127).

Therefore, the approach taken by KCDC in managing land use effects on the roading network ignores important recommendations provided by Transit New Zealand.

Opportunities for coordination of roading policies are also available in the cross boundary issues section of each district and regional plan and regional policy statement. The majority of these documents acknowledge the importance of maintaining a consistent approach to land transport, though specific methods in which to accomplish this are not offered. For instance, the MDC District Plan identifies the cross boundary issue of arterial roads, however, this Plan does not provide a specific method to deal with the integrated management of roads.

Road Design Part B: Incorporation of Greenway Concepts in Road Design

As identified in Chapter One, roads can be used to enhance biodiversity by acting as corridors to provide linkage between isolated patches. However, the potential for greenway concepts to be incorporated into roading design and management in the case studies has been largely ignored by the authorities outlined in Table 4.2. The majority of documents recognise the purpose of the road to be for transportation only. For instance, land transport policies in the Regional Policy Statements prepared by WRC and MWRC are limited to the promotion of efficient transportation systems which meet community needs while minimising adverse environmental effects. As the purpose of an RPS is to provide guidance for resource management in the region, these documents pose a powerful tool for advocating the incorporation of greenway concepts in road design. However, this opportunity is not recognised.

KCDC is the only authority which recognises the road as performing other purposes than merely transportation. In the Transport Section of the District Plan, the District Council is required to "develop a walking and cycleway system in co-operation with landowners, and other agencies linking areas of open space, ecological reserves, schools, commercial and community facilities, public transport and residential neighbourhoods" (1995:127). This is to be accomplished through surplus land within the Sandhills Bypass designation (Ibid, 1995). In addition, the RDC's District Plan recognises that the road must be designed so that it can accommodate various purposes, including landscaped berms. These berms could be used as vegetated roadsides which act as corridors to link patches. Yet, these are the only documents which consider the road as performing non-transportational [greenway] purposes.

Road Design Part C: Impediments From Road Safety to Using Road as Greenway

As identified in Chapter Three and Appendix 3, safety is paramount in road design. The use of the case study roads as potential greenways may be impeded by safety concerns. The document by Transit New Zealand (1994) *Highway Planning Under the RM Act* contains recommended controls on vegetation in relation to roads. For instance, territorial authorities should ensure that: vegetation plantings are sited and/or controlled so as to maintain adequate visibility at road intersections and property accesses; and to ensure that shading from roadside planting does not give rise to icing (Transit New Zealand, 1994:77).

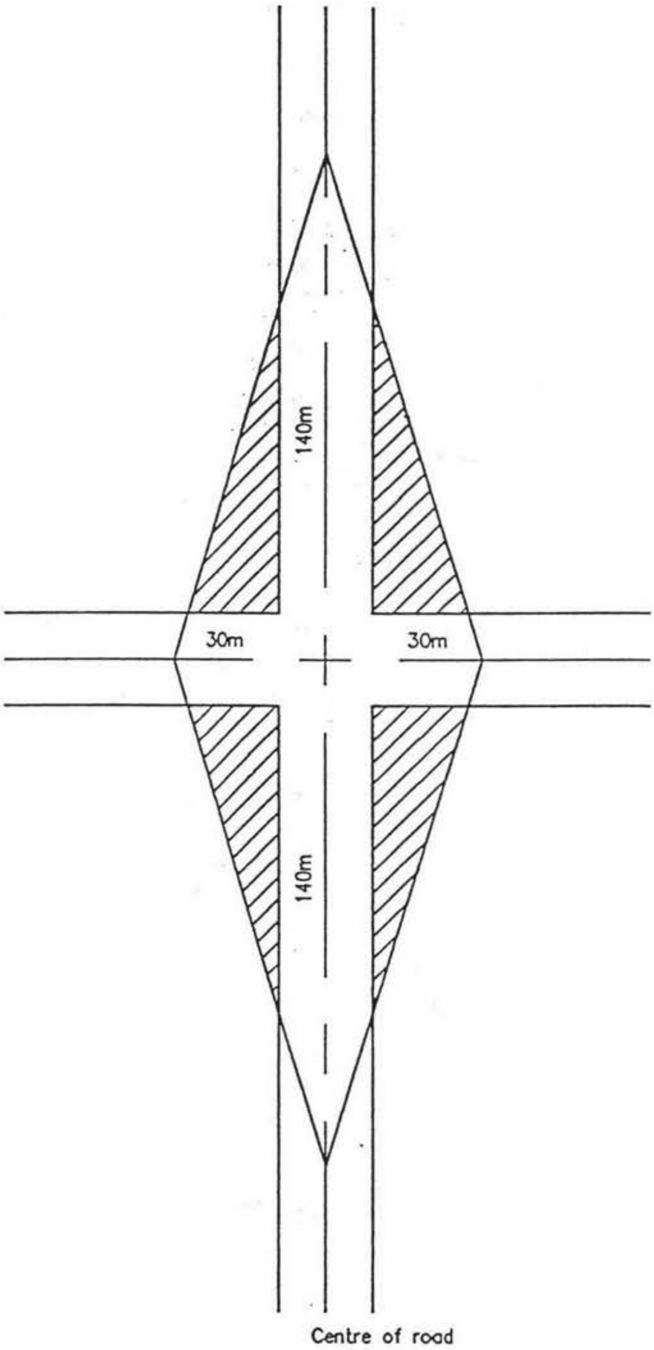
Provisions for these concerns are included in the MDC and RDC District Plans. For example, the MDC District Plan has included a rule for the rural zone which states that no trees which grow more than four metres in height are to be planted within 15 metres of any road edge (MDC, 1997:111). This rule is justified by visibility requirements, and the increased road maintenance from tree roots uplifting the road. Additionally, the RDC's District Plan states that no tree should be planted that would obscure sight distances from any road to a road intersection (RDC, 1995a:124), as shown in Figure 4.4. Furthermore, trees within plantation forests or shelterbelts shall not be located within 20 metres of the boundary [including road boundary] of any site contained in a separate certificate of title without the prior written permission of the owner of that adjoining site (RDCa, 1995:129). These rules may impede consideration of ecological corridors along roads in the Manawatu and Rangitikei districts. The Kapiti Coast District Plan does not contain any rules relating to vegetation planting near roads.

Biodiversity Protection Criteria

Part A: Focus and Coordination of Biodiversity Protection

Part A of the biodiversity protection criterion examines the focus of biodiversity protection and the extent of policy coordination between agencies involved in the management of biodiversity in each case study. Analysis of the planning documents contained in Table 4.2 reveals that while species protection is considered important, the agencies involved in the management of the case study areas are moving towards an "ecosystem" [or landscape] approach to biodiversity. An ecosystem management approach constitutes what landscape ecologists are advocating for [refer to Chapter Two]. WRC provides the best example of this. For instance, the WRC's Regional

Figure 4.4 Traffic Sight Lines at Road/Rail Level Crossings and Road Intersections for Rangitikei District Council (RDC, 1995)



Hatched areas are to be kept clear of buildings or other obstructions which might block sight lines. Dispensation to dimensions that are given may be possible through application to NZ Rail Limited dependent upon train movements in the area. Where there are 2 or more rail tracks, the 30m sight line applies from the centre line of the nearest track.

NOTE: All dimensions in metres

DIAGRAM NOT TO SCALE

Policy Statement (1995:153) recognises that ecosystems are dynamic [i.e.. in a state of constant change]; that protection of ecosystem processes are just as important as protection of species and other ecosystem components; and that everything is interconnected. Through this approach, the WRC (1995) emphasizes the importance of connectivity between patches.

The Kapiti Coast District Plan also acknowledges the importance of connectivity in the landscape. For instance, the District Plan contains a policy relating to the protection of linking corridors for fauna (KCDC, 1995:98). However, the policy coordination between WRC and KCDC in this instance may be more accidental than planned. For example, recognition of linking corridors in the District Plan may have resulted from the public antipathy towards the proposed Sandhills Bypass, which has in turn made KCDC strive for a more environmentally friendly road design. In addition, the District Plan does not explicitly recognise the ecosystem approach taken in the Wellington Regional Policy Statement, and the policy relating to linking corridors is the only recognition of an ecosystem approach in this plan. Therefore, policy coordination in this case may be accidental, rather than a result of compliance to requirements by the RM Act hierarchy where plans and policy statements must not be inconsistent with the level above [Figure A3.4, Appendix 1.2].

Although the MWRC's Regional Policy Statement acknowledges the importance of wildlife corridors between significant habitats in the Issue Section, there is no explicit reference of wildlife corridors in subsequent objectives and policies. This may explain the lack of an ecosystem approach in the MDC and RDC District Plans, where focus is on the protection of significant patches, with only little recognition of landscape interactions. In addition, the Rangitikei District Reserves Management Strategy does not acknowledge the importance of landscape interactions, and focuses only on the protection of patches [reserves].

Analysis of the relevant CMS's and PNA Reports indicate that while species protection is still advocated, DoC is moving towards an ecosystem approach (DoC, 1996; 1997). Throughout these documents, there is explicit recognition of the importance of interactions between landscape elements. For instance, in the Hawke's Bay CMS (DoC, 1994a:48), DoC states that more consideration is required to maintaining and enhancing natural processes across all lands [integrated management] and of achieving corridors [stepping stones] in co-operation with other landowners. Additionally, in the Wanganui CMS (DoC, 1997:226), DoC "will take a more proactive approach through ecosystem management" where individual species protection is required. Therefore, the agencies involved in management of the three case studies use a varied approach to biodiversity protection.

Biodiversity Protection Criteria Part B: Identification and Understanding of Biodiversity Protection

As outlined earlier, Part B of the biodiversity protection criterion examines the extent to which the authorities understand the requirements of biodiversity management. The analysis will focus on management by the relevant district councils, and not regional councils as these are not significantly involved in the protection of the case study patches, with the exception of providing guidance for the region. Analysis is performed according to the following guidelines provided by Froude (1995), which aim to enhance the understanding of biodiversity protection required by territorial authorities.

The RM Act requires councils to make provision for the protection of outstanding natural features [Section 6(b)] and significant indigenous vegetation and significant habitats of indigenous fauna [Section 6(c)] (Froude, 1995:20). The creation of heritage schedules/registers in conjunction with the preparation of their district plans is one way for territorial authorities to address these requirements. According to Froude (1995), schedules identify *inadequately* protected areas where district plan rules could assist in their protection [though, this does not preclude inclusion of formally protected patches in the schedule]. As the majority of inadequately protected patches fall on private property, improving the awareness of landowners and the community [who may be unaware of the ecological values of natural patches on their properties] is imperative to achieving protection status. Thus, consultation with landowners when preparing schedules is of crucial importance and should be conducted prior to the inclusion of a schedule in a proposed district plan. In order for the schedule to be effective, a comprehensive district plan/annual plan package is required which addresses: incentives, education, and district plan objectives, policies and rules (Ibid, 1995:23).

Each of the district councils [Rangitikei, Manawatu and Kapiti Coast] have prepared heritage registers which identify patches of significant value in the district. However, these heritage registers lack some of the above requirements, which in turn may hinder the effectiveness of protection approaches in each district. The RDC and KCDC district plans suggest that, although each council intends to inform landowners of heritage features on their property, this will occur after the heritage site has been included in the proposed district plan. For instance, the KCDC's district plan (1995:90) intends to "inform owners...about registered heritage features", which implies that the heritage site has already been included in the register by the time KCDC informs the landowner. This may have the effect of alienating landowners from their land. A loss of private property rights may be felt as the site has been included in the district plan [without consultation] and is therefore subject to district plan rules, which may limit the use of the heritage site by the landowner. This has recently occurred in several districts throughout New Zealand [for example: Far North and Banks Peninsular District Councils] where territorial authorities have included heritage sites in the district plan heritage schedule without prior notification of the landowner. Landowners have subsequently objected stating a loss of property rights and imposive costs incurred from protecting the "public good". The issues associated with private property conservation are discussed further in Appendix 1.1. In response to these problems, the Far North District Council is rewriting it's District Plan. This will impose great and unnecessary costs on the District Council.

In order to counter the above problem of landowner negativity, Froude (1995) argues that some councils may exclude sites of significant heritage at the landowners request. The MDC has taken this step. Heritage places where landowners do not favour protection of are excluded from the Manawatu District Plan heritage register, and are therefore not subject to district plan rules or other protection mechanisms. However, this approach reduces the likelihood that the council will adequately address the RM Act requirements outlined earlier (Froude, 1995). For example, if a resource consent applicant requested to modify a heritage site that has been excluded from the register, the council has no statutory basis [such as a rule] to prevent or limit the activity from affecting the site. To avert this problem, comprehensive and timely consultation with landowners should be carried out prior to the notification of the plan (Ibid).

The district plans prepared by KCDC and RDC offer incentives [for example: rates relief], financial contributions [for instance fencing], and voluntary mechanisms to landowners who protect significant sites identified in the heritage register. In addition, both councils intend to educate landowners to raise awareness of heritage sites (KCDC, 1995:89-90; RDC, 1995a:76-77). MDC, on the other hand, proposes to take a more "supportive" rather than "leading" role of other agencies involved in the provision of education and incentives for private property conservation (MDC, 1997:11). Therefore, the MDC District Plan does not include incentives or education provisions that will help landowners in conserving private property. This, along with the exclusion of important patches in the heritage register, impedes the effectiveness of MDC's approach to protecting significant heritage patches.

Biodiversity Protection Criteria Part C: Extent to Which Greenway Objectives are Recognised in the Protection of Patches and Corridors

Table 3.1 outlines the objectives which may be pursued when implementing the greenway concept. Part C of the biodiversity protection criterion investigates the extent to which these purposes have been recognised in the policies of planning documents relevant to the case studies. The analysis reveals that most of the objectives identified in Table 3.1 are recognised. All relevant agencies [DoC, regional and district councils] acknowledge the importance of patches and corridors for the protection and enhancement of: biodiversity, water quality, recreation, culture, history, public access, and amenity. The regional and district councils also use the protection of patches and corridors when addressing natural hazards. For instance: the provision of open space buffers along flood prone areas (KCDC,1995), and the implementation of riparian management to prevent erosion (MWRC, 1995b; WRC, 1995). Additionally, DoC uses the protection of corridors and patches to provide education and raise public awareness of conservation.

The only greenway objectives which are not addressed in the documents relate to: expression, public safety, and development control. Regarding this latter objective, the district councils in particular, have ignored an enormous opportunity to control development through mechanisms which support greenway initiatives, such as planting of vegetation or greenbelts.

Coordination Between Agencies in the Management of Scenic Outlook

The third criterion mostly examines the degree of policy coordination between agencies involved in the management of scenic outlook in State Highway 54 and Pohangina Valley East Road case studies. The MDC District Plan defines the "view shafts from the Stormy Point lookout" as an outstanding landscape in the district (MDC, 1997:19). To preserve these views, MDC intends to negotiate specific covenants with surrounding landowners on land uses to the north and west of this lookout (Ibid). This provision addresses the issue identified earlier in this chapter relating to the potential conflict between the protection of scenic outlook and enhancement of corridors near the greenway.

As mentioned earlier in this chapter, part of the landscape which constitutes the views from Stormy Point is managed by RDC. Hence, in order to preserve the view, a coordinated approach between RDC and MDC in the management of Stormy Point is required. Yet, there is no sign of coordination in the respective district plans. For instance, when identifying the importance of the Stormy Point lookout, MDC should indicate that part of this landscape is managed by RDC, which requires an integrated approach. Additionally, management of this landscape could be identified as a cross boundary issue in both district plans, yet this has not occurred.

There is evidence of coordination between the MWRC and Rangitikei and Manawatu District Councils in regard to scenic values. The Manawatu-Wanganui Regional Policy Statement recognises the scenic qualities for the Rangitikei and Pohangina Rivers and valleys as regionally significant landscapes. These scenic values are protected in the MDC and RDC district plans. Implicit coordination exists between WRC and KCDC. Although views are not significant in the Sandhills Bypass case study, the WRC's Regional Landscape Plan intends to maintain views toward the significant landscape features viewed from State Highway One [which can also be viewed from the proposed Sandhills route]. These views include Kapiti Island and Mt Wainui [adjacent to Paekakariki, Map 1] (WRC, 1996). KCDC plans to protect outstanding landscapes through its District Plan [such as the foothills of the Tararua Ranges and Kapiti Island] from adverse environmental effects, through ensuring any new development is not visually dominant (KCDC, 1995). The Kapiti Coast District Plan therefore implicitly acknowledges views identified as being important in the WRC's Regional Landscape Plan.

CONCLUSIONS

The aim of this analysis is to ascertain the degree of policy support for utilising roads as greenways, including the extent of policy coordination between relevant case study agencies. Several conclusions can be made. Firstly, the policy documents relating to the Sandhills Case Study generally support the use of a road for incorporating both transportational and non-transportational needs. However, the policy documents relating to State Highway 54 and Pohangina Valley East Road case studies do not generally provide for greenway concepts in road design. The use of State Highway 54 and Pohangina Valley East Road as greenways may also be impeded by district plan requirements relating to road safety. Both Manawatu and Rangitikei District Plans contain rules relating to visibility, ice and road maintenance which may potentially limit planting along the roadside, and therefore the use of these roads as greenways. The degree to which these factors influence road design will be determined in the following chapter.

A second conclusion is that the agencies involved in the management of the case studies take a varied approach to biodiversity protection. While some agencies have explicitly recognised the importance of landscape interactions and processes, others are still focusing on the protection of patches, with little recognition of movements between landscape elements. The potential importance of regional policy statements in providing guidance for resource management throughout the region is also revealed through this analysis.

Thirdly, the analysis has revealed that the approaches taken by the district councils for biodiversity protection may reduce the likelihood of addressing RM Act requirements. In all three case studies, the consultative approach taken by the district councils may impede the effectiveness of the biodiversity protection approaches in the district plans. Either a lack of consultation with landowners, or a lack of negotiation and associated supporting methods to help private property conservation has been exhibited by the district councils involved in management of the case studies. Therefore, these approaches may limit the efficacy of a greenway to protect biodiversity values along the case study roads.

Fourthly, it can be concluded that, while the RM Act establishes a hierarchy of plans and policy statements where consistency within and between each level is required, coordination between these documents is lacking. Poor coordination has been revealed in terms of road management, biodiversity protection and scenic views, particularly between district councils. In addition, where policy documents are coordinated, this coordination may be more accidental rather than as a result of the RM Act requirements. Thus, in order to implement greenway roads in New Zealand, management changes may be required to increase the extent of coordination between spatially related agencies and between the different levels of government.

The next chapter analyses the applicability of the greenway concept to each case study road. The "connectivity concept" devised by Fedorowick (1993) will be applied to each case study, so that potential impediments and opportunities to managing roads as greenways can be identified and discussed.

CHAPTER FIVE

CASE STUDY MAP ANALYSIS

This chapter analyses the applicability of the "greenway" and "connectivity" concepts to the case study roads. As identified in Chapter Two, linkage between patches and corridors in the landscape is essential to the design of greenways. By connecting patches and corridors in the landscape, the greenway concept can be used to achieve the connectivity required in theory. Traditionally, roads have been viewed adversely in regard to the environment, with their purpose seen only as providers of transportation. However, the design of roads as greenways may enable future roads to have multipurpose objectives including providers of wildlife corridors, and thus establishing a framework for restoring the ecological integrity of an area. Greenways could therefore be used to minimise the adverse environmental effects of the roading network.

As outlined in Chapter Four, an examination of the pattern of elements in the landscape is required when siting greenways. According to Thorne (1993:37), this requires examining the spatial arrangement of landscape elements by keeping in mind how pattern influences ecological integrity [Chapter Two] of the landscape. In some cases existing landscape pattern may be conducive to greenway design. For instance, where stream corridors and large patches of green space remain undeveloped, the landscape elements needed for greenway planning may already be in place. The existing landscape pattern may also act as a constraint, such as in a highly fragmented urban landscape.

Existing landscape pattern of the case study roads will be analysed to determine opportunities and constraints for enabling the additional use of road reserves as greenways. Suggestions will be also provided as to how authorities can maximise the use of the proposed Sandhills Bypass as a greenway so that the adverse environmental effects are minimised. There are two aspects to this analysis. First, each case study is examined according to the degree of connectivity between existing patches and corridors in the landscape. Where connectivity is low, new corridors or patches are placed through applying the "connectivity concept" suggested by Fedorowick (1993). The basis of this analysis is derived from Fedorowick's (1993) research on developing a restoration method for the southern Ontario rural landscape in Canada. The purpose of the analysis is to identify potential corridors or patches of vegetation or wetlands which may enhance the connectivity between existing elements in each case study landscape. The suggested corridors and patches which can be incorporated onto the road reserves are key priorities in this thesis. Second, this exercise will identify potential opportunities and constraints for using the case study roads as greenways.

CASE STUDY METHODOLOGY

The analysis will be performed according to the procedure outlined in Figure 5.1. This procedure is explained below.

ASSUMPTIONS TO ANALYSIS

The analysis is guided by four assumptions [Figure 5.1]. These assumptions are important in determining information requirements for each case study.

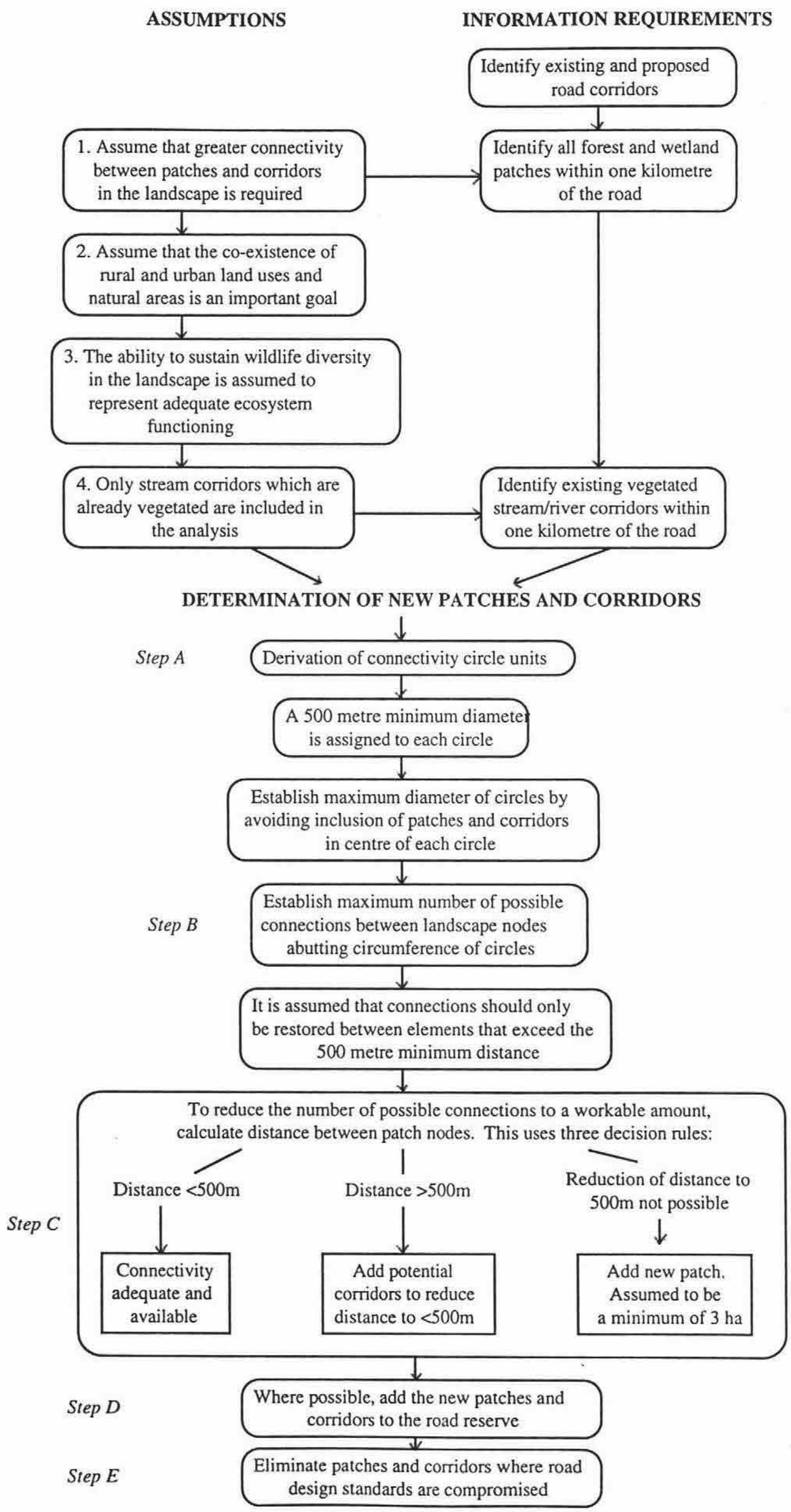
1. That greater connectivity between patches and corridors in the New Zealand landscape is required.

The first assumption is based on ideas from the discipline of landscape ecology, which are outlined in Chapter Two. Landscape ecologists suggest that landscapes should be spatially structured with patches and corridors where isolated patches are connected to counter the effects of fragmentation (Ahern, 1995).

2. That the co-existence of rural/urban land use and natural areas is assumed to be an important goal in the case study areas.

As Chapter Four outlines, the case studies are located in landscape matrices which are dominated by rural or peri-urban land uses. Therefore, the placement of new corridors or patches will take the best possible advantage of the existing landscape pattern so that benefits are provided to both agriculture and ecosystem functioning. Harris and Sheck (1991) suggest that the principal [cultural] corridors that can be enhanced as wildlife corridors include: roadways, recreational and linear riparian

Next Page: Figure 5.1 Assumptions and Methodology for the Application of the Connectivity Concept


ASSUMPTIONS
INFORMATION REQUIREMENTS
Identify existing and proposed road corridors
1. Assume that greater connectivity between patches and corridors in the landscape is required
Identify all forest and wetland patches within one kilometre of the road
2. Assume that the co-existence of rural and urban land uses and natural areas is an important goal
3. The ability to sustain wildlife diversity in the landscape is assumed to represent adequate ecosystem functioning
4. Only stream corridors which are already vegetated are included in the analysis
Identify existing vegetated stream/river corridors within one kilometre of the road
DETERMINATION OF NEW PATCHES AND CORRIDORS
Step A
Derivation of connectivity circle units
A 500 metre minimum diameter is assigned to each circle
Establish maximum diameter of circles by avoiding inclusion of patches and corridors in centre of each circle
Step B
Establish maximum number of possible connections between landscape nodes abutting circumference of circles
It is assumed that connections should only be restored between elements that exceed the 500 metre minimum distance
Step C
To reduce the number of possible connections to a workable amount, calculate distance between patch nodes. This uses three decision rules:
Distance <500m
Distance >500m
Reduction of distance to 500m not possible
Connectivity adequate and available
Add potential corridors to reduce distance to <500m
Add new patch. Assumed to be a minimum of 3 ha
Step D
Where possible, add the new patches and corridors to the road reserve
Step E
Eliminate patches and corridors where road design standards are compromised

forests, hedges and ownership boundaries such as fences. Thus where possible, new corridors or patches will follow roads, existing shelter belts, unvegetated streams or fencelines to provide minimal disturbance to present land use.

3. That the ability of the landscape to sustain wildlife diversity is assumed to represent adequate ecosystem functioning.

As identified in Chapter Two, high wildlife diversity indicates a healthy soil, an adequate mixture of agricultural land use and natural cover, low levels of toxicants, and therefore adequate ecosystem [landscape] functioning. Hence, the third assumption is based the idea that high wildlife diversity represents adequate ecosystem functioning. Since wildlife can only persist where there is adequate food, shelter and breeding habitat, wildlife is considered as a suitable indicator (Fedorowick, 1993:9-10).

4. That only existing vegetated stream corridors are included in this analysis.

In order to reduce the number of potential connections to a workable amount, Fedorowick (1993) assumes that all existing stream corridors are restored to suitable corridor connections. However, the assumption that *all* stream corridors would be restored to suitable corridor connections reduces the authenticity of the analysis in this thesis. In New Zealand, the landscape is different in that areas are often dominated by numerous small tributary streams, many of which are unvegetated [for instance, the State Highway 54 case study, which is discussed in Chapter Four]. Therefore, the assumption that all existing streams are vegetated cannot be used. Instead, only vegetated stream corridors are included. Unvegetated stream corridors are identified for restoration only where they follow the route of new potential corridors. Likewise, Fedorowick assumes that all road corridors are vegetated. Yet, this cannot be assumed in the New Zealand landscape since most road corridors seem to be unvegetated.

INFORMATION REQUIREMENTS

To determine the extent of connectivity within each case study landscape, two major types of information are required [Figure 5.1]:

1. The identification of the existing and proposed road corridors.

The routes of State Highway 54 and Pohangina Valley East Road are provided on the topographic maps [Maps 5.3 and 5.4, Appedix 4]. The Sandhills Bypass route was sketched from maps by KCDC (1995) and Beca Carter Hollings & Ferner Ltd & Traffic Design Group Ltd (1996) on to the topographic maps, as the relevant topographic map does not delineate the proposed Sandhills route.

2. *Identify all patches or corridors within one kilometre of the road.*

The radius of one kilometre was selected to minimise the extent of analysis. All patches and corridors outlined on the topographic maps are identified. This includes any existing indigenous, mixed and exotic vegetation patches and corridors. Shelter belts, but not individual trees, are considered for analysis. Both formally and informally protected patches and corridors of vegetation and wetlands are identified. As discussed in Chapter Two, the general idea of greenways refers to a natural, green way based on protected linear corridors which will improve environmental quality (Little, 1990:4). Hence, existing protected patches and corridors will be an important starting point in the design of the greenway. Protected areas which constitute unvegetated areas, such as a gravel river bed, are also considered in this analysis, as these provide opportunities for restoration so that they can support adequate wildlife movement.

DETERMINATION OF NEW PATCHES AND CORRIDORS

Determining the approximate number and appropriate location of new patches and corridors in each case study involves a five-step process. These steps are defined as Steps A to E on Figure 5.1. The first three steps of the process are devised by Fedorowick (1993). Steps A to C assess the extent of connectivity in each case study and assign new patches and corridors in areas of poor connectivity. As this thesis is concerned with designing roads as greenways, Step D constitutes the placement of new patches and corridors on each case study road reserve. Step E uses engineering criteria from the relevant territorial authorities to indicate where the these patches and corridors can not be placed in the road reserve due to conflictions with road safety. Hence, Step E determines the extent to which road design standards influence the use of roads as greenways.

Step A: Derivation of Connectivity Units

Step A entails drawing circles between interconnected landscape patches in the poorly connected portions of the study areas to define the connectivity units. The minimum diameter of each circle is derived from the distance small mammals will travel from patch to patch in the open landscape (Fedorowick, 1993). The 500 metre minimum diameter suggested by Fedorowick (1993) is used in this analysis because of the deficiency in ecological information on the movement of wildlife in the New Zealand landscape [refer to Chapter One for further discussion]. However, this diameter was calculated using data about the movement of small mammals over a landscape, not birdlife as is the main characteristic of New Zealand's landscape. Since the majority of small mammals in the New Zealand landscape are pests [Chapter One], there are difficulties of deriving connectivity units as envisaged by Fedorowick (1993). However, Bueno (et al. 1995) [Chapter Two] suggests that well researched and planned ecological management and restoration monitoring should counter any problems associated with corridors. The maximum diameter of each circle was established by trying to avoid the inclusion of patches and corridors in the centre of each circle. Elements in the centre can reduce the total number of possible connections depending on the size of the particular element (Fedorowick, 1993:12).

Step B: Establishment of possible connections

Step B requires identification of the maximum number of possible connections between the patches and corridors. To determine the best way to improve the linkage between patches, potential connections are placed between the landscape nodes [refer to Glossary] which abut the circumference of each circle. The connections are not necessarily consistent with existing landscape structure as the aim of this step is to maximise the number of possible *direct* connections between nodes. Since adequate wildlife movement at 500 metres represents ecosystem functioning, connections are generally only restored between patches and corridors that exceed the minimum distance of 500 metres (Fedorowick, 1993).

Step C: Reducing the number of connections to a workable amount

The maximum number of possible connections between patches are then reduced to a workable amount in Step C. This is performed by calculating the distance between patch nodes. The three decision rules devised by Fedorowick (1993) are used in this analysis [Figure 5.1]. Where the distance is less than 500 metres, the connection is considered to be adequate and available. Where the distance exceeds 500 metres, corridors are added to the existing landscape structure to reduce the distance to less than 500 metres. In some instances, the distance between patches may not be reduced by the addition of corridors because the nature of the existing landscape structure. For instance, land use may preclude the placement of corridors. In these cases, new patches are added to encourage species movement. Fedorowick (1993:15) suggests a minimum area of three hectares for new patches, this being the minimum size that will support a mesic interior [refer to Glossary] to prevent the replacement of flora by alien species. Where possible, the new patches are placed at the junction of the connectivity circle units, or in the most appropriate locations to minimise the number of additional corridor connections required. For instance, patches may be placed on unvegetated streams where the stream corridor can provide linkage to adjacent patches.

Step D: Adding new patches and corridors to the road reserve

Step D involves modification of the placement of the new patches and corridors so that they are located in the road reserve. As this thesis concentrates on using the roadway as a greenway to enhance connectivity in the landscape, the placement of patches and corridors on private property is avoided as much as possible, and the new landscape elements are moved into the road reserve.

Step E: Eliminating patches and corridors where minimum sight distances from intersections are required

Chapter Three and Appendix 3 identify the main factors which must be considered in road design. As safety is paramount, road design must ensure that the minimum sight distance is provided for at all times (O'Flaherty, 1975). Step E involves obtaining the minimum sight distances from each district plan, and ensuring that the new patches and corridors placed on the road reserve in Step D, do not conflict with the minimum sight distance required from intersections. The minimum sight distance varies due to the standards set by each territorial authority, and the design speed for each road.

PROBLEMS WITH CONNECTIVITY CONCEPT

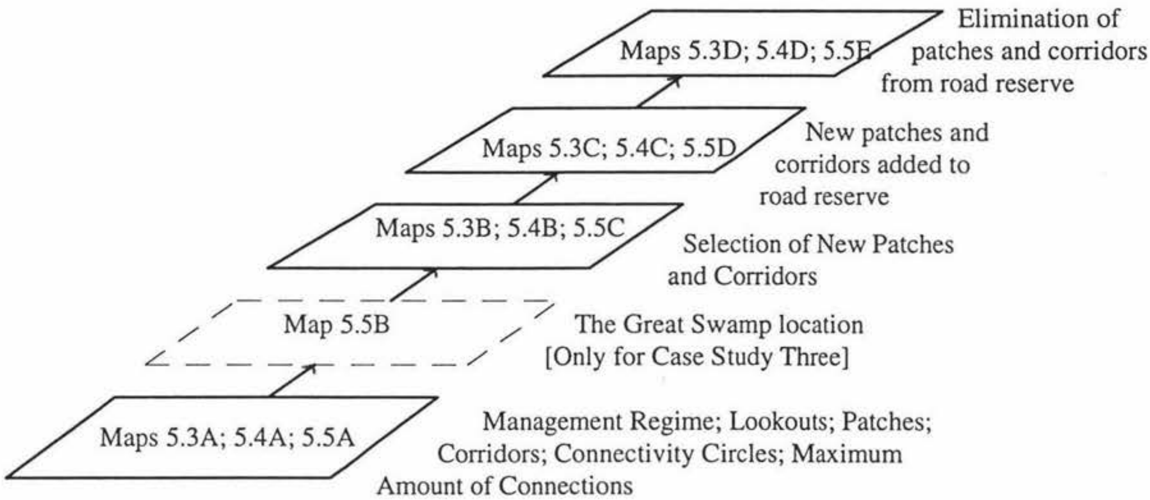
When applying Fedorowick's connectivity concept to the case study areas, one major problem is deciding which part of the patch should be connected by the greenway corridor. In many cases, there are numerous places where the patch could be joined to the corridor, though no suggestions were offered by Fedorowick to clarify choice. A further problem relates to the assignation of the maximum diameter for circles. As outlined earlier, Fedorowick establishes the maximum diameter of each circle by trying to avoid the inclusion of patches and/or corridors in the centre of each circle. In some instances it was difficult not to include any patches or corridors [particularly the roads] in the circle centre. For example, often the circle had to transverse the road in order for the circle to encompass patches. Additionally, the one kilometre radius defining each study area ignores existing and potential corridors and patches just outside of the study area. Therefore, recognition of other opportunities for linkage with patches and corridors outside of the study area is important for the successful application of Fedorowick's connectivity concept.

MAP OVERLAYS

Each case study has a series of map overlays, which are based on topographic maps [scale 1:50 000]. However, it is recognised that since these maps were published (1993) the case study landscapes analysed may have changed in terms of land use and vegetation cover. For instance, through personal observation, more significant areas of the State Highway 54 case study landscape have been planted in exotic forestry. This includes one landowner who has started planting most of his farm [approximately 1 200 acres, north of Rewa] in pinus radiata. Therefore, it is acknowledged that there are other opportunities available for achieving a connected landscape which have not been included in this analysis. Additionally, the topographic maps identify only a selection of the fencelines available. The analysis only uses the selection identified, though it is recognised that there are numerous other opportunities for corridors to follow fencelines that are not shown on these maps.

Figure 5.2 provides a diagrammatic view of the map overlays. The map overlays are contained in Appendix 4, although the final overlay for each case study is included in this chapter. In the State Highway 54 and Pohangina Valley East Road case studies there are four map overlays. The first overlay [Maps 5.3A and 5.4A, Appendix 4] identifies the existing patches and corridors; their management regime [including their protection status]; and potential or actual lookout points in the case study areas. The first overlay also defines the connectivity circle units and identifies the maximum number of possible connections between patches, as devised by Fedorowick. This overlay consists of Steps A and B on Figure 5.1. The second overlay [Maps 5.3B and 5.4B, Appendix 4] applies the decision rules outlined in Step C on Figure 5.1.

Figure 5.2 Map Overlays Used for Each Case Study



The third overlay [Maps 5.3C and 5.4C, Appendix 4] involves placing the patches and corridors into the road reserve, as in Step D in Figure 5.1. The fourth overlay [Maps 5.3D and 5.4D, Appendix 4] reveals where patches and corridors conflict with the requirement of minimum sight distances from intersections and can not be placed on the road reserve to improve landscape connectivity. This constitutes Step E on Figure 5.1.

Analysis of the Sandhills Bypass case study entails five map overlays [Maps 5.5A-D, Appendix 4, Map 5.5E]. The first Sandhills overlay [Map 5.5A, Appendix 4] is the same as the first overlay for the above case studies, simply locating existing patches and corridors; their management regime; and locating the connectivity circle units and the maximum number of possible connections. Potential or actual lookout points are not identified in this case study as views are not important. The second overlay [Map 5.5B, Appendix 4] delineates the original location of "The Great Swamp" [Figure 4.2]. This overlay is included in the Sandhills analysis to determine how the proposed road - if designed as a greenway - could be used to enhance connections between remnant wetlands of The Great Swamp. Therefore, the placement of new patches and corridors in the Sandhills case study [Map 5.5C, Appendix 4] will maximise opportunities which enable restoration of The Great Swamp. Where the new patches and corridors fall outside of The Great Swamp boundary, the new landscape elements will constitute vegetation patches. This constitutes the third map overlay. The fourth overlay identifies where the new patches and corridors can be incorporated into the Sandhills road reserve [Map 5.4D, Appendix 4]. The fifth overlay [Map 5.4E, Appendix 4] shows those patches and corridors which cannot be included in the road reserve, due to minimum sight distance requirements from proposed intersections along the route.

In order to enhance the connectivity between landscape elements in each case study, the patches and corridors that cannot be placed in the road reserve due to minimum sight distance requirements [on the final overlay for each case study] would have to be relocated onto private property, as shown on Maps 5.3C, 5.4C and 5.5D [Appendix 4]. Planting of these patches and corridors would therefore have to consider the issues of private property conservation, outlined in Appendix 1.1.

ANALYSIS OF CASE STUDIES

The following discussion will outline the characteristics of the existing patches and corridors within each case study. This discussion will examine the potential opportunities and constraints for enhancing each of the three case study roads as greenways. An explanation of why each new corridor and patch has been recommended in each case study is provided. In the case of the Sandhills Bypass, the proposed mitigation measures of the road are outlined to determine how a potential greenway can help minimise the adverse environmental effects of the road. Chapter Four contains further information about the characteristics of each case study.

CASE STUDY ONE: STATE HIGHWAY 54

As identified in Chapter Four, State Highway 54 transverses a highly fragmented landscape where a lot of the original vegetation has been removed. Therefore, much the landscape surrounding State Highway 54 lacks sufficient connectivity for wildlife movement considered important by greenway theorists. The most fragmented part of this landscape involves the lower half of the study area, where the analysis has resulted in placement of seven new patches and eleven individual corridors [Map 5.3B, Appendix 4]. In the top half of the study reach, most existing patches or corridors are within the 500 metre radius, providing adequate connections between landscape elements for wildlife movement.

Map 5.3A [Appendix 4] distinguishes the patches and corridors which are formally protected by DoC or MDC; informally protected [identification in the Manawatu District Plan or as a Recommended Area for Protection (RAP)]; and unprotected [on private land]. Formal protection for the Sinclair Property forest patch is at present being negotiated with the landowner concerned (MDC, 1997). Although the protected patches and corridors are generally widely spaced and not connected, they provide an important starting point for the design of a potential greenway. In order to implement a greenway along State Highway 54, integration would be required between all of these different management regimes.

Most of the patches and corridors in the State Highway 54 study reach are associated with or follow stream corridors which lead into the Rangitikei River. The study reach also includes shelter belts, which are classified as line corridors by Forman and Godron (1986) [Table 2.1, for definitions of stream and line corridors]. Roads also constitute "line corridors". Map 5.3A [Appendix 4] shows that most of the patches or corridors are native scrub or forest, and are generally small in size. These patches and corridors have characteristics resembling the "chronic disturbance remnant patches". "Introduced planted patches" are also present in the State Highway 54 study area [Table 2.2 defines the above-mentioned patches].

Selection of New Patches and Corridors *[Step C, Figure 5.1]*

In Case Study One, two major opportunities exist for taking advantage of the existing landscape pattern when designing new corridors and patches. There are numerous unvegetated streams throughout the study area. Parts of the Rangitikei River are also unvegetated. Chapter Two outlines the requirements of good riparian management. Improved riparian management of these streams and river would provide excellent opportunities for wildlife movement. Fencelines also provide opportunities to plant corridors of vegetation between isolated patches. These could act as shelter belts and providers of shade for stock or crops. The study area contains a school, and while no new landscape elements have been placed at the school, it is recognised that the large open spaces provided by schools may create opportunities for wildlife habitat establishment [for instance, refer to Hough, 1989).

Erosion prone steep topography also offers opportunities for landowners to plant areas of unstable land. While this is also relevant in Case Study Two, it is particularly important in Case Study One as State Highway 54 transverses a very steep landscape. Therefore, steep topography is recognised as a potential opportunity for private landowners to enhance linkage between landscape elements. In regard to roads, planting to reduce erosion may be considered a potential opportunity for enhancing roads as greenways. For example, road reserve planting can provide protection from slips (O'Flaherty, 1975). Conversely, while opportunities for planting may be provided by steep topography, it may also act as an impediment, particularly in the case of a steep cliff face.

In some cases, the existing landscape structure of State Highway 54 presents problems when trying to achieve a network of vegetation patches and corridors. Existing structures such as: houses, associated farm buildings [home/habitation patches], powerlines and airstrips constrain the placement of patches or corridors throughout the study reach. Maintenance of important vantage points such as the Stormy Point Lookout [refer to Map 5.3A, Appendix 4] are additional impediments to connecting patches of vegetation throughout the case study. As discussed in Chapter Four, new vegetation patches may conflict with the views derived from the Stormy Point Lookout.

Road corridors [other than State Highway 54] which are not being considered for greenway applicability may also impede the continuation of wildlife movement corridors. For example, where a new corridor connection crosses a road, a break in the corridor would result. Therefore a patch could be placed in the road reserve so that consistency with Fedorowick's third decision rule is maintained [Figure 5.1].

Map 5.3B [Appendix 4] identifies the new patches and corridors recommended to improve connectivity between existing landscape elements along the State Highway 54 study reach. Table 5.1A discusses each new patch and corridor with reference to: the location of each new connection; regarding patches: the linkages required to connect the new patch to existing patches; and general comments concerning difficulties or opportunities in placing the new connection. In most cases, corridors will only be discussed where they are independent of new patches.

Table 5.1A Placement of Patches and Corridors, SH 54

Corridor or Patch Number	Location of New Connection	Connections Required to Link Other Patches	Comments
Patch One	At junction of connectivity circles, fencelines and stream	New corridors via fencelines	Located on private property, close to SH 54
Corridor One	Follows fencelines and existing shelter belts	Not Applicable [n/a]	Located on private property

Table 5.1A [Continued]

Corridor or Patch Number	Location of New Connection	Connections Required to Link Other Patches	Comments
Corridor Two	Follows Waituna Stream	n/a	Located on private property
Corridor Three	Near junction of circles, follows fencelines	n/a	Located on private property
Corridor Four	At junction of circles, follows fencelines, existing shelter belt and stream	n/a	Located on private property
Corridor Five	Follows stream corridor, fencelines and existing shelter belts	n/a	Located on private property
Patch Two	Located on stream corridor	New corridors via unvegetated streams	Located on private property, placement limited by airstrip
Patch Three	Located on stream corridor	New corridors via unvegetated streams	Located on private property, placement limited by airstrip
Patch Four	Located at junction of stream and fenceline	New corridors via streams and fenceline	Located on private property, placement limited by airstrip, Stormy Point and powerlines; land is steep
Corridor Six	Follows fencelines and existing shelter belt	n/a	Located on private property, to provide linkage as Stormy Point limits placement of corridors or patches
Corridor Seven	Follows fencelines and streams	n/a	Located on private property, no streams or fencelines to follow at lower end between shelter belt and patch
Patch Five	Located between two stream corridors, at junction of connectivity circles	New corridors via stream	Located on private property, located downslope of Stormy Point to prevent view being blocked
Patch Six	Located on Rangitikei Valley Road reserve	New corridors via fencelines	Located between houses and may impede sight distance for property access
Patch Seven	Located at end of fencelines	New corridor via fencelines	Located on private property, near houses and vehical track, no linkage on northern side of patch
Corridor Eight	Follows Rangitikei River	n/a	Follows marginal strip along river
Corridor Nine	Follows stream and fencelines	n/a	Located on private property, crosses bridge

Table 5.1A [Continued]

Corridor or Patch Number	Location of New Connection	Connections Required to Link Other Patches	Comments
Corridor Ten	Follows Rangitikei River	n/a	Located on private property; Steep cliff between SH 54 and river precludes placement of corridor
Corridor Eleven	Follows stream corridor and part of SH One	n/a	Located on private property, links patches outside of study area

Placement of New Corridors and Patches in Road Reserve *[Step D, Figure 5.1]*

Map 5.3C [Appendix 4] identifies the patches and corridors which can be placed on the road reserve of State Highway 54 so that this road can be used as an ecological corridor for wildlife movement, as well as for transportation. Excluding sight design guidelines analysed in Step E, the major impediments to enhancing the State Highway 54 road reserve as a greenway concerns the view shaft derived from the Stormy Point lookout. Therefore, the addition of new patches and corridors along the road reserve are not placed where they may conflict with the view. Table 5.1B identifies the patches and corridors recommended and adjustments required to enhance connectivity along the State Highway 54 road reserve.

Table 5.1B Placement of Patches and Corridors in SH 54 Road Reserve

Corridor or Patch Number	Adjustments Required for New Connection	Comments
Patch One	Corridors which follow fencelines and stream are extended to join road reserve. Corridor linking Patch One and Sinclairs Bush is shifted to road reserve	Shifted from private land to road reserve
Corridors Three and Five	Shift Corridors Three and Five into road reserve to provide linkage between existing patches	Shifted from private land to road reserve
Patch Two	Corridor linking Patch Two and lower patch is shifted to road reserve; new corridor running perpendicular to road connects Patch Two and Three via fencelines, Corridor Six is shifted to road reserve	Shifted from private land to road reserve
Patch Seven	No major adjustment required, corridor linking Patch Seven and lower patches is also moved into road reserve	Shifted from private land to road reserve
Corridor Nine	No major adjustments required: shift all of Corridor Nine into road reserve	Shifted from private land to road reserve

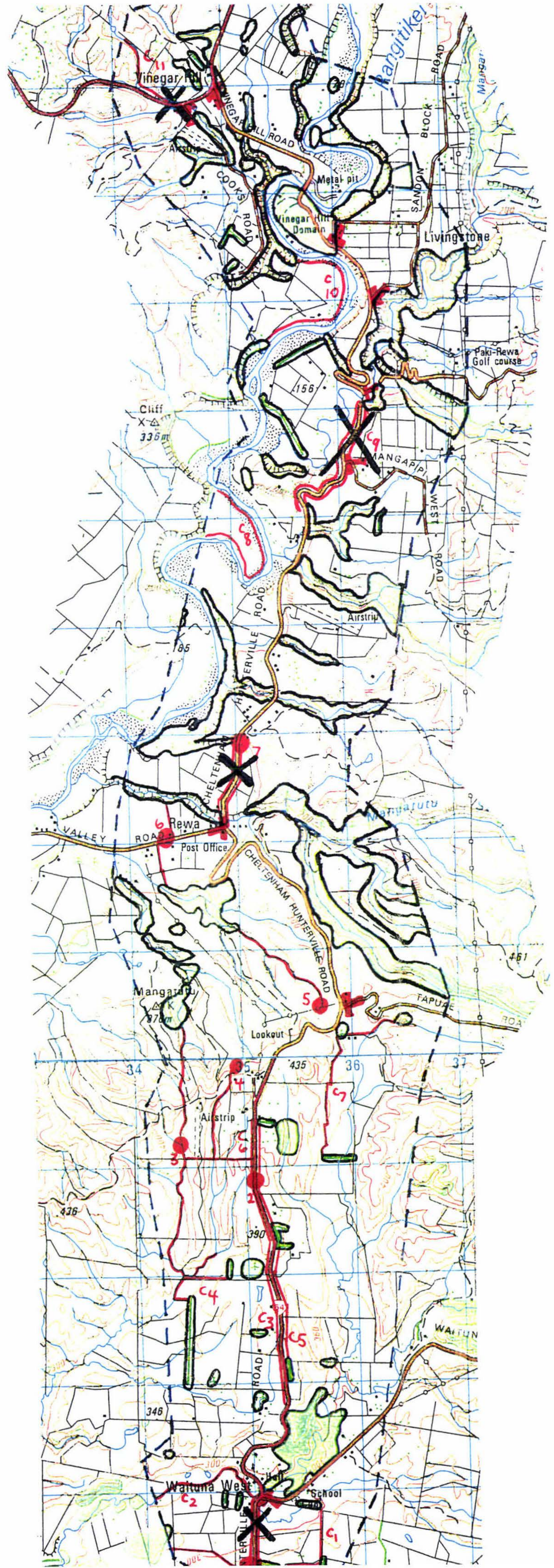
Elimination of Patches and Corridors in Road Reserve *[Step E, Figure 5.1]*

Chapter Three contains a discussion about the importance of safety in road design. Map 5.3D identifies the patches and corridors outlined in Table 5.1B that cannot be placed in the State Highway 54 road reserve as they compromise the minimum sight distance required from intersections [for further reference, see Figure 3.3]. The Manawatu District Plan [which operates between Waituna West and the Rangitikei River Bridge] requires from each intersection where traffic speed is 100 kilometres per hour, a minimum sight distance of 500 metres to be retained along the road corridor so that traffic safety is not compromised. As shown on Table 3.3, this is double the minimum sight distance requirement provided in Transit New Zealand guidelines, and rather resembles the "optimum sight distance" suggested on Table 3.3.

The Rangitikei District Plan [which operates between the Rangitikei River Bridge and the State Highway One intersection] uses the Transit New Zealand guideline of 250 metres for minimum sight distance from an intersection where traffic speed is 100 kilometres per hour. These minimum sight distances are used to assess the safety requirements of placing the patches and corridors along the State Highway 54 road reserve. The patches and corridors that conflict with these requirements are identified in Table 5.1C. It is recognised that the hazard of ice can be a result of planting in the road reserve. The MDC and RDC District Plan rules outlined in Chapter Four, provide for this. However, icing will not be considered in this thesis because of the difficulty in locating hazardous areas.

Table 5.1C Elimination of Patches and Corridors From SH 54 Road Reserve

Corridor or Patch Number	Adjustments Required or Elimination
Corridor linking Patch One and Sinclair Property Bush	The Waituna Valley Road and SH 54 intersection requires sight distance of 500 metres either side, hence the top part of this corridor conflicts with safety and may have to be removed.
Corridor linking Patch Seven	The Rangitikei Valley Road and SH 54 intersection requires sight distance of 500 metres therefore this corridor may need to be removed from the road reserve.
Corridor Nine	Corridor Nine is within the 500 metre minimum sight distance of both Mangapipi West Road and Lower Pakihikura Road intersections. The top half of Corridor Nine may have to be removed due to sight conflictions. However, the lower half of Corridor Nine could remain since this part of SH 54 is very windy with only low speed limits possible. Hence, sight distance would be reduced anyway.
Corridor Eleven	The intersection of SHs One and 54 requires a minimum sight distance of 250 metres. Therefore part of Corridor Eleven may need to be removed so that safety is not compromised.

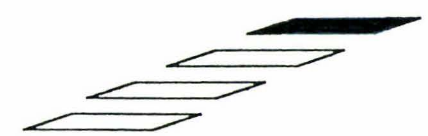


NORTH

Greenway To The Future? The Use of Greenways In Roading Management
Rochelle Viles

LEGEND:
Existing patches and corridors
Proposed patches
Proposed corridors
Patches and corridors that cannot be placed in road reserve
Intersections

Note: Map Derived From Topographic Maps: NZMS 260 T22 Edition 1 1983 [1990] and T23 Edition 1 1982 [1996]. Standard legend applies for all base information.
Scale: 1:50 000



Map Number: 5.3D
State Highway 54 Overlay Number: Four

Map 5.3D reveals that some of the new patches and corridors can be placed on the road reserve without compromising road safety requirements. Therefore, in the locations where new patches and corridors are placed on Map 5.3D, State Highway 54 can be used as a greenway to achieve ecological objectives and provide linkage to the adjacent landscape elements. In order to maintain connectivity throughout the landscape, the patches and corridors that conflict with sight distances would have to be replaced on to private property, as in Map 5.3B. Planting of the remaining patches and corridors which are located on private land would require landowner consent and willingness. In this instance, the issues regarding private property conservation in Appendix 1.1 become important, and protection mechanisms which address landowner concerns [such as costs] should be considered, rather than methods that place stringent controls and high costs on the landowner.

CASE STUDY TWO: POHANGINA VALLEY EAST ROAD

As identified in Chapter Four, the landscape surrounding Pohangina Valley East Road in some cases exhibits similar characteristics as the State Highway 54 case study. However, the landscape surrounding Pohangina Valley East Road is more extensively vegetated than that surrounding State Highway 54. Map 5.4A [Appendix 4] reveals that the majority of patches and corridors in the Pohangina case study are within the 500 metres distance assumed by Fedorowick (1993) to be adequate for wildlife movement in the open landscape. Totara Scenic Reserve provides a significant portion of this vegetation, which is also connected to the Ruahine State Forest Park outside of the study boundary. Only two new corridor connections and patches are recommended throughout the study reach.

Map 5.4A [Appendix 4] delineates the patches and corridors which are formally protected by DoC and MDC; informally protected [identification in the Manawatu District Plan or a RAP]; and unprotected [on private land]. The majority of formally protected patches are managed by DoC, though the Totara Scenic Reserve is owned and managed by the Manawatu District Council. "The Retreat" occupies private land but has been identified by DoC as a Recommended Area for Protection. Generally, these areas are connected with unprotected patches and provide an important starting point for the design of the greenway. In order to implement a greenway along the Pohangina Valley East Road, integration would be required between each of these different management regimes.

Similar to the State Highway 54 example, the majority of corridors and patches in the Pohangina case study are associated with the Pohangina River and its tributary streams [Map 5.4A, Appendix 4]. Compared to the Rangitikei River, the Pohangina River corridor is better vegetated with almost continuous vegetation along its margins. As Map 5.4A shows, patches in the top third of the study reach and most tributary "stream corridors" are dominated by native forest or scrub. They are generally small in size with the exception of Totara Scenic Reserve and The Retreat. These patches and corridors are classified as "chronic disturbance remnant patches". "Introduced planted patches" are dominant in the lower two thirds of the case study. Pine plantations provide a mostly continuous riparian corridor along the Pohangina River south of Totara Scenic Reserve [see Table 2.2 for definitions of chronic disturbance remnant patches and introduced planted patches]. Shelter belts forming "line corridors" also follow parts of the river corridor and fencelines in the study reach [refer to Table 2.1 for definitions of stream and line corridors]. Roads throughout the study area are also line corridors.

Selection of New Patches and Corridors *[Step C, Figure 5.1]*

As with the State Highway 54 case study, opportunities for new corridors and patches to follow the existing landscape pattern consist of fencelines and unvegetated stream corridors. Improved riparian management of these streams [also discussed in the State Highway 54 case study section above] could provide excellent opportunities for wildlife movement. Fencelines also provide opportunities to plant corridors of vegetation between isolated patches. As with the State Highway 54 case study, the study area contains a school [see Map 5.4A Appendix 4]. Although a patch has not been placed in the school, it is acknowledged that schools could be potential wildlife habitat providers (for further reference, see Hough, 1989).

Some parts of the Pohangina Valley East Road existing landscape pattern provide problems when placing new corridors and patches. Map 5.4A [Appendix 4] identifies houses and associated farm buildings [home/habitation patches, Table 2.2] which could constrain the placement of patches or corridors throughout the Pohangina case study landscape. Map 5.4A also outlines possible vantage points along the Pohangina Valley East Road. New patches and corridors are placed so that they do not conflict with these concerns.

Map 5.4B [Appendix 4] identifies the two new patches and corridors suggested to enhance connectivity between existing landscape elements along the Pohangina Valley

East Road study area. Table 5.2A discusses each new patch and corridor with reference to: the location of each new connection; regarding patches: the linkages required to connect the new patch to existing patches; and general comments concerning difficulties in placing the new connection. In most cases, corridors will only be identified where they are independent of new patches.

Table 5.2A Placement of Patches and Corridors, Pohangina Valley East Road

Corridor or Patch Number	Location of New Connection	Connections Required to Link New Patch	Comments
Patch One	Located at junction of fencelines	New corridors following fencelines and existing shelter belts	Located on private land; no opportunities on map to link Patch One with lower patches
Corridor One	Follows fencelines	n/a	Located on private land, crosses over a vehicular track and building
Patch Two	Located on a stream corridor	New corridors via stream	Located on private land; placement is limited due to potential view shaft from "Fairview" towards the River and buildings
Corridor Two	Follows stream and fencelines	n/a	Located on private land

Placement of Patches and Corridors in Road Reserve *[Step D, Figure 5.1]*

Map 5.4C [Appendix 4] identifies the patch and corridor which can be placed on the Pohangina Valley East Road reserve to enhance the use of the road as a greenway. The Fairview outlook prevents the addition of new patches or corridors in this vicinity. The view shaft north of The Retreat may also impede the use of the road reserve as a wildlife corridor. There is only one opportunity in the Pohangina Valley East Road case study where the road reserve can be used as an ecological corridor. Table 5.2B identifies this connection and the adjustments required.

Table 5.2B Placement of Patches and Corridors in Pohangina Valley East Road Reserve

Patch Number	Adjustments Required to Connection	Comments
Patch One	New patch and corridor shifted to road reserve	Shifted from private land to road reserve
Corridor One	Shifted Corridor One to road reserve	Shifted from private land to road reserve

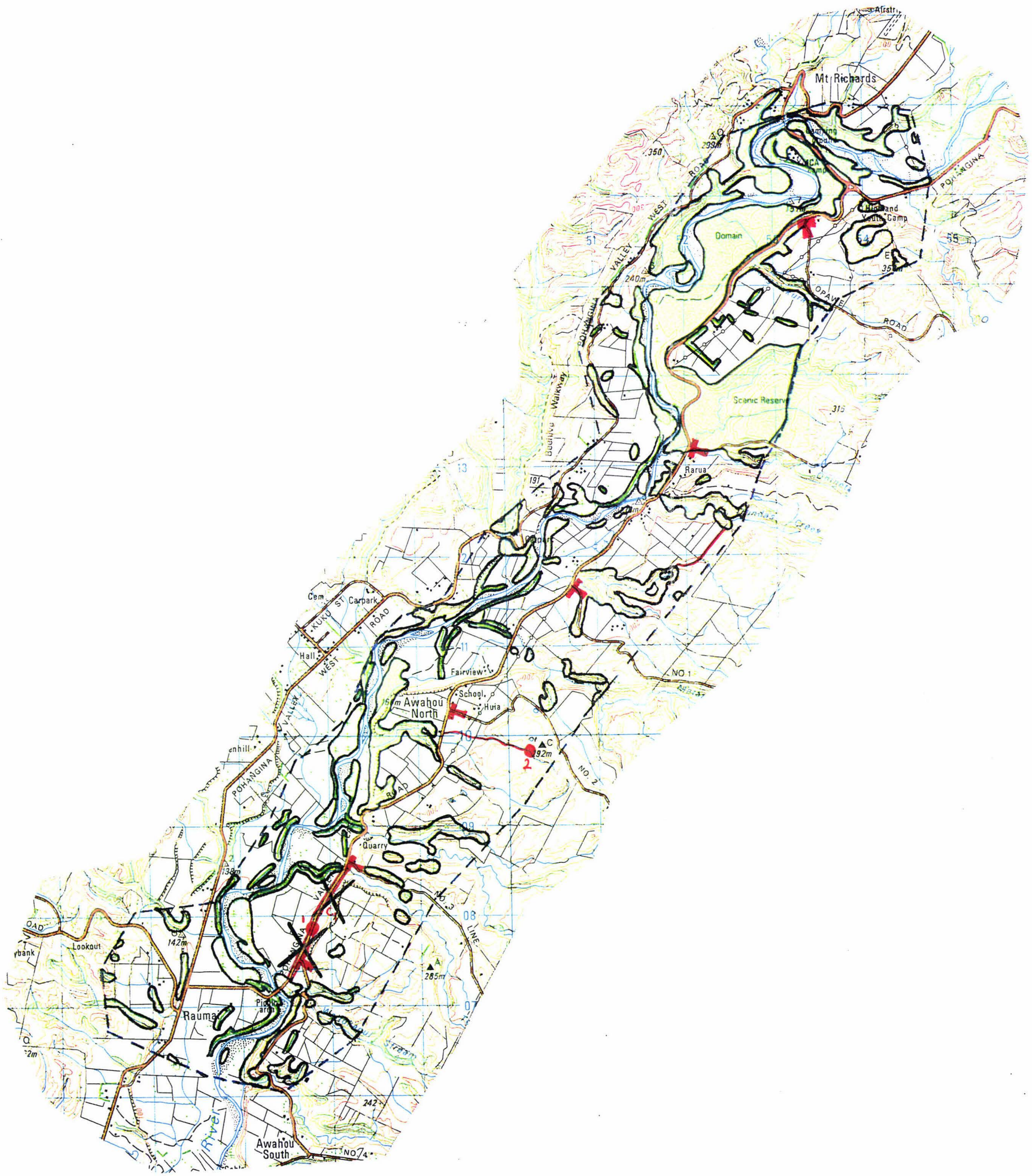
Elimination of Patches and Corridors in Road Reserve *[Step E, Figure 5.1]*

Chapter Three outlines the design features that must be incorporated in road design to achieve road safety. Map 5.4D identifies the new connection from Table 5.2B [and Map 5.4C] that cannot be placed in the Pohangina Valley East Road reserve as it jeopardizes the minimum distance required from intersections set by MDC. As discussed under the Case Study One heading, MDC establishes a minimum sight distance of 500 metres from intersections on roads where the speed is 100 kilometres per hour. Table 5.2C outlines the elimination and/or adjustments required to this connection. The occurrence of ice [discussed earlier this chapter and in Chapter Four] along the road through planting in the road reserve is also recognised as a potential impediment for managing the Pohangina Valley East Road as a greenway. Though, ice hazards are not analysed in this thesis.

Table 5.2C Elimination of Patches and Corridors From Pohangina Valley East Road Reserve

Patch Number	Elimination and/or Adjustments Required
Patch One and Corridor One	The No. 4 Line intersection with Pohangina Valley East Road requires a minimum sight distance of 500 metres on either side to ensure road safety. Therefore, Patch One may have to be removed as it compromises the minimum sight distance. Corridor One may also have to be removed due to conflictions with the No. 3 Line Intersection sight distances.

Map 5.4D reveals that the Pohangina Valley East Road is limited in its potential for being used as a greenway. Traffic safety [eg. visibility] and potential lookout points are the overriding factors precluding consideration of the road as an ecological corridor. Additionally, since the landscape surrounding the road is already well vegetated [and most patches are within the 500 metre distance required for adequate wildlife movement, as suggested by Fedorowick (1993)], new patches and corridors are not required to the same extent as the State Highway 54 case study. Therefore, the road does not need to be used to restore connectivity in the landscape. A possible conclusion from this case study is that the potential use of roads as greenways [where ecological objectives are dominant] may be most relevant in landscapes which are highly modified and fragmented environments, because well vegetated landscapes [such as Pohangina Valley East Road] already contain sufficient connectivity outside of the road reserve. The patch and corridors that can not be placed on the road reserve would have to be replaced on private land, as in Map 5.4B. Therefore, the



NORTH

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LEGEND:

Existing patches and corridors	
Proposed patches	1
Proposed corridors	C1
Patches and corridors that cannot be placed in road reserve	X
Intersections	T

Note: Map Derived From Topographic Map: NZMS 260 T23 Edition 1 1982 [1996]. Standard legend applies for all base information.
Scale: 1:50 000

Map Number: 5.4D
Pohangina Valley East Road Overlay
Number: Four

issues associated with private property conservation [outlined in Appendix 1.1] would have to be addressed when planting these landscape elements.

CASE STUDY THREE: SANDHILLS BYPASS

As outlined in Chapter Four, the Sandhills Bypass cuts across a highly modified landscape in which urban and rural land uses have resulted in drainage of the original wetland network and clearance of most indigenous vegetation. The resultant landscape contains numerous drainage ditches created to carry run off from the surrounding farmland (Opus International Consultants, 1997a). Map 5.5A [Appendix 4] shows that most patches and corridors in Case Study Three are generally widely spaced and not connected. Therefore, new connections are proposed throughout the study area.

The patches and corridors which are formally protected by KCDC and DoC; informally protected [identification in the Kapiti Coast District Plan or a RAP]; and unprotected [on private land] are identified on Map 5.5A [Appendix 4]. Many of these patches are only identified in the Kapiti Coast District Plan's Heritage Register or are identified by DoC as RAPs, hence they are not formally protected. The majority of these patches are located on private property. Therefore, the inclusion of patches such as these into the greenway network would have to consider the issues associated with private property conservation, outlined in Appendix 1.1. The remaining patches are protected by DoC and the Kapiti Coast District Council. The protected patches and corridors in this case study provide an important starting point for the design of the greenway. The successful application of a greenway along the Sandhills Bypass would require the integration of these patches and their associated management regimes.

The topographic maps used for Maps 5.5 [Appendix 4] distinguish between forest patches and wetland patches. Many of the existing patches are forest remnants, with a smaller number of wetland patches. Unlike the first two case studies, existing patches in the Sandhills landscape tend not to be associated with streams and rivers. The majority of forest patches identified on Maps 5.5 [Appendix 4] are "chronic disturbance remnant patches" of scrub, with a few "introduced planted patches". "Line corridors" in the Sandhills study reach are typically shelter belts, drainage ditches, and roads. Refer to Tables 2.1 and 2.2 for definitions of: chronic disturbance remnant patches; introduced planted patches; and line corridors.

Selection of New Patches and Corridors *[Step C, Figure 5.1]*

In Case Study Three, fencelines and streams provide opportunities for the placement of new corridors and patches, both of which are discussed under the previous two case studies. Map 5.5A [Appendix 4] identifies the Waikanae River and numerous drainage ditches as opportunities for the placement of new patches and corridors in the Sandhills landscape. Map 5.5A also identifies a school [discussed in the previous case studies] and a golf course in the vicinity to the Sandhills Bypass. Hough (1989) states that these areas contain potential opportunities for the establishment of wildlife patches and corridors - particularly habitats which are less sensitive to human presence. In addition, sewage treatment plants offer vast opportunities for the creation of wildlife habitats (Ibid). Although not contained within the study boundary, the Sandhills Bypass travels close to the sewage treatment plant located at Te Harakiki Swamp [Map 5.5A, Appendix 4]. Therefore, this site could be considered as a future wildlife habitat provider.

Several potential barriers to achieving a connected landscape in the Sandhills Bypass case study are identified in Map 5.5A [Appendix 4]. Urban development [including the settlements of Waikanae, Paraparaumu and Raumati] poses the most significant impediments when designing a network of patches and corridors in the Sandhills landscape. Inversely, Hough (1989, 1990) suggests that the best wildlife habitats in cities are often those with the greatest impediments to human use. For instance, airports provide enormous opportunities to create new habitats for wildlife. In addition, major industry [including hospitals] is a significant supporter and instigator for creating wildlife habitat in and around urban environments (Ibid). However, the present climate of privatisation may influence the extent to which hospitals support ecological objectives in New Zealand.

The issue of other roads preventing the continuation of wildlife corridors [identified in the State Highway 54 case study] is also an impediment in this case study. As outlined in Chapter One, views are not important in this case study and therefore do not hinder the placement of corridors and patches. The following discussion briefly outlines the main adverse environmental effects which may arise from the proposed Sandhills Bypass, and how they can be mitigated. This will provide an indication as to how a potential greenway could ameliorate the adverse environmental effects created by roads.

Map 5.5A, [Appendix 4] identifies the wetlands which are directly affected or are close to the proposed road development. Mitigation measures in respect of these wetlands include: restoration and enhancement of remaining wetlands, and where a loss to wetlands occurs [El Rancho wetlands and Osbornes Swamp] restoration or enhancement of an equivalent area of nearby wetland (Opus International Consultants, 1997a). The proposed greenway recommended in this section could be used for providing guidance regarding the placement of new wetland patches and corridors included in this mitigation measure.

The proposed route crosses several streams, including the lower Waikanae River which is a highly significant resource in the area as it provides habitat for several nationally threatened animal and plant species, and functions as an ecological corridor for may other species (Ibid). Consequently, the proposal includes bridge construction which could create adverse effects on the wildlife habitats in the River. Mitigation measures proposed by KCDC in respect the bridge include: enabling sufficient height of the bridge over the river and its banks to allow the creation and maintenance of suitable indigenous plant corridors under the bridge, and the replacement or enhancement of riparian vegetation elsewhere along the River. These mitigation measures will be detailed in an Ecological Rehabilitation Plan for wetland, streams and river margin enhancement and maintenance (Ibid). Again, the greenway design recommended in this section could be used to guide the placement of these mitigation measures.

The proposed route also crosses several man-made drainage ditches created to carry run off from the surrounding farmland (Ibid). Therefore, the proposal will require new drains, drain diversions and culverts. This work could be mitigated through redesigning the drainage networks to optimise new drainage patterns and minimising the number of culverts (Ibid). Thus, the proposed greenway could be used as a framework for the implementation of this mitigation measure. For instance, the new stormwater systems could be designed in line with the new patches and corridors which are recommended in this case study so that new drains provide connections between new or existing wetland patches. Therefore, the proposed road could be designed to help restore the original wetland network outlined in Figure 4.2 and Map 5.5B [Appendix 4].

Landscape mitigation measures involve reshaping batters [or side-slopes, as discussed Appendix 3] to blend with existing landforms, and revegetating these with either planting or grass. The opportunity to create a habitat corridor as well as a transport corridor is also recognised as an important mitigation measure. The enhancement or extension of existing wetland and native vegetation patches would also be possible by creating a habitat corridor along the Sandhills route (Ibid). This mitigation measure is ideally what any potential greenway examined in this thesis aims to achieve. The potential greenway could be used to attain the above mitigation measures, and therefore could be used to ameliorate the adverse environmental effects arising from the road.

Map 5.5C [Appendix 4] identifies the patches and corridors which are suggested to improve the connectivity between existing patches and corridors within the Sandhills case study area. Table 5.3A reviews each new patch and corridor with reference to: the location of each new connection; regarding patches: the linkages required to connect the new patch to existing patches; and general comments concerning difficulties and opportunities in placing the new connection. In most cases, corridors are only discussed where they are independent of new patches. Wetland patches are suggested where they fall within the boundary of The Great Swamp [Map 5.5B, Appendix 4], but outside of this boundary, forest patches are recommended.

Table 5.3A Placement of Patches and Corridors, Sandhills Bypass

Corridor or Patch Number	Location of New Connection	Connection Required to Link Other Patches	Comments
Corridor One	Whareroa Stream and drains, at junction of connectivity circles	n/a	Wetland connection, located on private property
Patch One	Located on road reserve, at junction of connectivity circles	Linked to nearby patches via drains and fencelines	Wetland patch
Patch Two	Located at junction of connectivity circles and drain	Linked to Patch One via drains	Wetland patch, placement limited by urban development, located on private property
Corridor Two	Follows fencelines	n/a	Forest connection, placement limited by urban development, located on private property
Patch Three	At junction of connectivity circles, on road reserve	New corridors via road reserve	Wetland patch, placement limited by urban development
Patch Four	Near road reserve, joins existing shelter belt, junction of connectivity circles	New northeastern corridor via fencelines, crosses stream. New northwestern corridor via drains. Joined to Patch Three via road reserve	Wetland patch, placement limited by urban development, located at edge of urban and rural land use, on private property

Table 5.3A [Continued]

Corridor or Patch Number	Location of New Connection	Connection Required to link Other Patches	Comments
Patch Five	Located at junction of connectivity circles in area of open space	New connections via boundary of school then transverses streets	Forest patch, placement limited by urban development
Patch Six	Located on road reserve where drains meet road	New connection via drains	Wetland patch, placement limited by urban development [eg: hospital]
Patch Seven	Located on road reserve where drains meet road	New connections via drains and corridor along road reserve	Wetland patch, placement limited by urban development[eg: hospital]
Patch Eight	Located on drain between streets	New connection via drains	Wetland patch, placement limited by urban development, located in semi-urban land
Patch Nine	Located near Mazengarb Road to provide linkage between Patch Eight and Ratanui Swamp	New connection via drain and existing shelter belts	Wetland patch, located on private property
Patch Ten	Located near unmetalled road	New connections via drains which lead into the Waikanae River	Wetland patch, located on private property
Corridor Three	Follows Waikanae River	n/a	Wetland connection, Waikanae River identified as significant to DoC, KCDC, WRC
Corridor Four	Follows Waimeha and Ngarara Streams, cuts through road reserve	n/a	Wetland connection, placement limited by urban development, cuts through golf course
Corridor Five	Follows fencelines	n/a	Wetland connection, located on private property
Patch Eleven	Located on road reserve, at junction of connectivity circles	New connection via drains and road reserve	Wetland patch
Patch Twelve	Located where stream and road reserve join, at junction of connectivity circles	New connection via drain, stream and fencelines	Wetland patch
Patch Thirteen	Located where stream meets road reserve, at junction of connectivity circles	New connection via drains and road reserve	Wetland patch
Patch Fourteen	Located at junction of Gary Road and drains	New connection via drains	Wetland patch, located on private land

Placement of New Corridors and Patches in Road Reserve *[Step D, Figure 5.1]*

Map 5.5D [Appendix 4] identifies the patches and corridors which can be placed on the proposed road reserve of the Sandhills Bypass to maximise the use of the road as a greenway. Several patches and corridors are already placed on the Sandhills Bypass road reserve, since in several instances, urban development prevented placement of patches and corridors, leaving the road reserve the only potential opportunity for wildlife habitat. Table 5.3B discusses the additional patches and corridors which could be incorporated into the Sandhills road reserve, and the adjustments required for the new connections.

Table 5.3B Placement of Patches and Corridors in Sandhills Bypass Road Reserve

Patch or Corridor Number	Adjustments Required For Connection	Comments
Corridor linking Patch One and existing wetland to the northwest	Corridor follows road reserve	Shifted from private land to road reserve
Patch Four	Patch adjusted to above shelter belt, new corridor along road reserve then follows Wharemauku Stream	Shifted from private land to road reserve
Corridor linking Patches Six and Seven	Corridor shifted from drain to road reserve	Shifted from private land to road reserve
Patch Ten	New connection via road reserve	Shifted from private property to road reserve, meets Waikanae River at proposed Sandhills Bridge
Corridor linking Patch Eleven and Twelve	Corridor shifted from drain and fencelines to road reserve	Shifted from private land to road reserve

Elimination of Patches and Corridors in Road Reserve *[Step E, Figure 5.1]*

Nine new intersections will be required along the Sandhills Bypass (Opus International Consultants, 1997a; Beca Carter Hollings & Ferner Ltd et al. 1996). The location of each intersection is shown on Map 5.5E. As discussed in Chapter Three, the design speed of a road determines the level of design standard to be applied to achieve road safety. The proposal for the Sandhills Bypass involves several design speeds, as shown on Table 5.3C. The Kapiti Coast District Plan does not establish minimum sight distance standards relating to intersections. However, the Plan does set minimum sight distance standards for private and commercial accesses, though Transit New Zealand (1994) deals with intersection sight distance and access sight distance standards separately. Therefore, the analysis will use the Transit New Zealand (1994) guidelines for minimum sight distance standards from intersections [Table 3.3]. To determine the minimum sight distance standards for the Sandhills

Bypass, the average of the design speeds provided along each stretch of road is used to evaluate the minimum distance required for adequate sight to and from intersections [Table 5.3C].

Table 5.3C Design Speeds and Minimum Sight Distances to and from Intersections Along the Sandhills Bypass (Opus International Consultants, 1997a; Transit New Zealand, 1994)

Sections of Sandhills Route	Design Speed (kilometres per hour)	Minimum Sight Distance (m)
Poplar Ave - Raumati Road	60-80	130
Raumati Road - Mazengarb Road	50-60	92
Mazengarb Road - Te Moana Road	60-80	130
Te Moana Road - State Highway One	80-100	210

Map 5.5E identifies the new connections from Table 5.3B [Map 5.5D] that cannot be placed in the Sandhills Bypass Road reserve due to possible conflictions with the minimum sight distance required from intersections. Table 5.3D discusses each elimination.

Table 5.3D Elimination of New Patches and Corridors Along the Sandhills Bypass Road Reserve

Patch or Corridor Number	Elimination and/or Adjustment Required
Patch Three	Patch Three falls on the Raumati Road and Sandhills Bypass intersection, which requires a minimum sight distance of 130 metres on the southern side and 92 metres sight distance on the northern side. Therefore this patch may have to be removed from the road reserve.
Corridor linking Patch Seven to existing northeastern patches	The intersection of Mazengarb Road and Sandhills Bypass requires a minimum sight distance of 92 metres on the southern side and 130 metres on the northern side. Patch Seven is more than 92 metres from the intersection, however, the corridor which links this patch to others along the road may have to be eliminated since it compromises the 130 metres required for safety.
Patch Twelve and Thirteen	The intersection of State Highway One and the Sandhills Bypass requires a minimum sight distance of 210 metres, therefore Patches Twelve and Thirteen and the corridor in between these patches may have to be eliminated to maintain the minimum sight distance.

Two major differences exist between the Sandhills Case Study and the previous two case studies. First, the Sandhills Case Study focuses on restoration of the original wetland network, compared to forest patches in Case Studies One and Two. Second, as the Sandhills Bypass transverses both urban and rural environments, there are a wider variety of landowners and land uses than in the previous two case studies.

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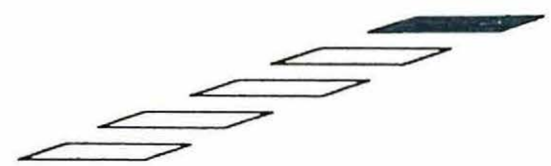
LEGEND:

Proposed Sandhills Bypass	
Existing patches and corridors	
Proposed vegetation patches	1
Proposed wetland patches	1
Proposed vegetation corridors	C1
Proposed wetland corridors	C1
Patches and corridors that cannot be placed in road reserve	X
Intersections	T

Note: Map Derived From Topographic Map: NZMS 260 R26 & Pt. R25 Edition 2 1993. Standard legend applies for all base information.
Scale: 1:50 000



Map Number: 5.5E
Sandhills Bypass Overlay Number: Five

Instead of dealing dominantly with landowners who farm, the Sandhills Case Study presents further opportunities for creating wildlife habitats in land uses including: industrial sites [hospital], airport, school, golf course, and peri-urban land which may become subdivided in the near future. Additionally, since the emphasis is on wetland patches, wetland vegetation [which may only be low in height] may not produce the same difficulties [such as conflictions with visibility for transport and aircraft safety], compared to the other two case studies where the new vegetation elements would typically be lowland forest, and because of its height, may conflict with visibility requirements.

As Table 5.3D and Map 5.5E show, only three new landscape elements conflict with the visibility requirements for intersections, while the remaining patches and corridors can still be placed on the road reserve. In order to achieve connectivity throughout the landscape, the patches and corridors which conflict with sight distances would need to be replaced on to private land. In this instance, issues of private property conservation would have to be addressed [Appendix 1.1].

The Sandhills Bypass road reserve contains enormous potential for use as a wildlife corridor as well a as transport corridor. The opportunity provided by this road to operate as a greenway may be a result of the lower design speeds along the route [Table 5.3C]. Slower design speeds enables a reduced minimum sight distance from intersections, such as 92 metres, as compared to the faster design speeds of 100 kilometres in Case Studies One and Two, where the minimum sight distance requires 250 and 500 metres visibility. Hence, slower roads may be more conducive to serving as greenways when traffic safety factors are considered.

CONCLUSIONS

This chapter has analysed the applicability of the "greenway" and "connectivity" concepts to each of the case study roads. The analysis reveals that where landscapes are already well vegetated and connected [for example, the Pohangina Valley East Road case study], the road does not need to be used to restore connectivity to the same extent as less connected and more fragmented landscapes [such as State Highway 54 and Sandhills case studies]. Therefore, the applicability of the greenway concept [as defined in this thesis] and connectivity concept is more relevant in significantly modified landscapes.

The major benefit derived from applying the concepts to these landscapes is that connectivity between landscape elements is enhanced, which in turn improves ecological integrity, or ecological health within the landscape [Chapter Two]. This benefit is despite management implications relating to pests [Chapter One and Two], and potential conflicts between planting and road safety requirements, and planting and scenic views. In addition, the greenway concept offers enormous potential in its application to mitigate the adverse environmental effects of the roading network.

The analysis shows that not all patches and corridors can be placed in the road reserves. Therefore, in order to achieve the connectivity required by greenway theorists, the application of these concepts in future landscapes will have to consider other opportunities in the New Zealand landscape which can provide wildlife habitats. Examples in urban areas include: hospitals, airports, schools, and new subdivisions. Opportunities in rural environments include: fencelines, streams and steep topography, though concerns relating to conservation costs and interference of private property rights must also be considered. Most importantly, wherever new landscape elements are placed, it is crucial that a coordinated approach to the management of the greenway is established since greenways typically transverse a multitude of different management jurisdictions.

The following chapter will discuss the findings of the analysis performed in this thesis. The benefits to future planners of the greenway and connectivity concepts and the issues for future research will be discussed. Recommendations as to how the relevant agencies can deal with the issues raised will also be offered.

CHAPTER SIX

CONCLUSIONS, RECOMMENDATIONS, ISSUES FOR FUTURE RESEARCH

This chapter will first synthesise the key findings identified in this thesis by revisiting the objectives used to guide the thesis. The research methods, namely the greenway and connectivity concepts, will be discussed in regard to their adequacy for this thesis, and the problems encountered when applying the connectivity concept. Recommendations as to how agencies can achieve greenway objectives will then be offered. Lastly, the issues for future research which have been raised throughout this thesis will be discussed.

THESIS OBJECTIVES REVISITED

This thesis aims to investigate the applicability of the greenway concept for achieving integrated management of the roading network and adjacent landscape in New Zealand. Roads by their very nature traverse natural and cultural landscapes with little respect for the environment in which they cross. Roads have been traditionally viewed as impediments to the environment. However, as discussed in Chapter One, roadsides contain significant conservation potential and if enhanced, could be managed as greenways to provide linkage to patches and corridors located in the adjacent landscape. As discussed in Chapter Three, New Zealand's diverse landscapes are greatly under-represented in conservation management. As a consequence, the need for the integration of public and private land uses with conservation is required. The application of greenways to roads has the potential to provide for the integration of a public land use with conservation, where currently poorly represented ecosystems could be incorporated within the road reserve boundary. In addition to improving New Zealand's conservation estate, the greenway concept provides enormous opportunities for minimising the adverse environmental effects from the roading network.

The first objective of this thesis explored the greenway concept. Discussions in Chapter Two reveal that the diverse nature of greenways makes the concept difficult to define succinctly, however, this diverse nature enables greenways to be applied in a multitude of situations, both natural and man-made environments. In general, greenways can be considered as linear networks of corridors and patches which provide a variety of functions, the most important of these being to counter the effects of landscape fragmentation, and hence protect biodiversity. The greenway applied in this thesis entails "a road reserve [including the road and roadside] in which planting is conducted along the roadside to enhance the roading network and provide linkage to the surrounding landscape matrix".

While a number of benefits can be derived from using greenways in landscape and roading management, there are also challenges facing the greenway concept [Chapter Two]. According to greenway theorists, these challenges are best addressed by understanding the overall landscape context to determined if the connection is desirable or even necessary. In addition, well researched and planned ecological management and restoration monitoring should reduce any negative effects from greenways. This is important for the New Zealand landscape since the management implications which arise from our uniqueness [for instance, in terms of the dominance of indigenous birdlife species and small mammal pest species] may warrant different management techniques than countries where the greenway concept has already been applied.

As roads cross a multitude of management regimes, this thesis reveals that a coordinated approach for the successful use of roads as greenways, is crucial between: conservation managers, road construction and management authorities, local government, utilities and landowners [Chapter Three]. Additionally, since a variety of uses occur within the road reserve, coordination between these agencies at the design, construction and management stages of greenway roads is essential. The New Zealand landscape management regime contains two principal agencies which could provide for coordination between the road reserve and adjacent landscape. The function of DoC to advocate for the conservation of natural and historic resources provides a potentially powerful role for ensuring the integration of conservation into the road reserve. Policy support is provided through conservation management strategies, which protect species regardless of the landownership regime [Appendix 1.2]. Integration could also be achieved through regional policy statements which provide guidance to territorial authorities for the integrated management of the region's natural and physical resources. This constitutes part of the second objective for this thesis which examined how the New Zealand roading network and landscape is managed presently, and where integration could be achieved for successful greenway application.

However, the integration of conservation into land use systems through DoC's advocacy role may be impeded as a result of limited resources and funding provided by the New Zealand Government to DoC. Conservation issues are generally accorded a low priority in terms of governmental concerns, and as a result, DoC is poorly funded. In addition, there is a high possibility that the general trend of recent government department cuts will continue. Therefore, the financial strength of DoC may deteriorate even more in the future. Incidentally, this may reduce DoC's advocacy and protection potential, where only the most important species and ecosystems [gauged by rarity] can be protected. Consequently, the much needed improvements to increase the representativeness of New Zealand's conservation estate may not be provided for.

Analysis of the management regimes of each case study in Chapter Four reveals that gaps still occur in policy coordination, despite the RM Act hierarchy of plans where consistency is required between and within each level of plans and policy statements. While recommendations regarding this concern will be offered later in this chapter, the main point to be made here is that - territorial authorities in particular - often provide only the bare minimum of coordination between adjacent authorities. Therefore, where the greenway concept is pursued, territorial authorities would need to become more proactive in the management of their boundaries, so that a unified approach to landscape and roading management is attained.

The analysis in Chapter Four has also revealed significant deficiencies in the approaches by territorial authorities regarding their management of patches and corridors. Hence, the attainment of RM Act requirements may be hindered as a result of: inadequate consultative processes between territorial authorities and landowners which do not provide for effective negotiation; the exclusion of important landscape elements from protection mechanisms; and in some instances, no district plan package [including: incentives, education, objectives, policies and rules] to support private property conservation.

The importance of proper consultation between landowners and territorial authorities is shown in the cases of Far North District Council and Banks Peninsular District Council. Therefore, it is crucial that councils adopt a comprehensive consultative approach for private property conservation throughout plan preparation for three reasons. Firstly, where appropriate conservation measures such as incentives are not offered, territorial authorities run the risk of repeating the previous management practices where landowners become antipathetic towards private property conservation due to the cost of protecting the "public good". This leads to the second implication that without proper consultation with landowners, the likelihood of achieving RM Act requirements will be reduced. Thirdly, by adopting a thorough consultative approach, territorial authorities will save money in the long run, for instance, from appeals or having to rewrite a plan.

ADEQUACY OF GREENWAY AND CONNECTIVITY CONCEPTS

The third objective guiding this thesis entailed applying the greenway and connectivity concepts to each of the case study roads. The analysis in Chapter Five discovered that parts of the landscape surrounding State Highway 54 lack the connectivity required by greenway theorists. Consequently, several new landscape elements would be required to achieve greenway objectives. Where the minimum sight distance guidelines for intersections do not limit the placement of patches and corridors in the road reserve, State Highway 54 could be utilised as an ecological greenway. Therefore, application of the greenway and connectivity concepts to State Highway 54 enables the road reserve to function as an ecological corridor in several places along the road reserve, which in turn enables the road to provide linkage to the surrounding landscape matrix.

The application of the connectivity concept to the Pohangina Valley East Road Case Study [Chapter Five] reveals that the landscape surrounding the road is already well vegetated with the majority of patches within the 500 metre distance required for adequate wildlife movement as suggested by greenway theorists. Resultantly, new patches and corridors are not required to the same extent as the other case studies. Hence, the road is not needed to restore connectivity in this instance. Additionally, where new landscape elements could be placed in the road reserve, these are limited by the minimum sight distances required to and from intersections. Therefore, the connectivity concept does not help to improve the Pohangina Valley East Road in terms of providing linkage to the surrounding landscape matrix. Of course, this does not limit the use of the road for achieving other greenway objectives, such as recreation and aesthetics.

The analysis in Chapter Five finds that the Sandhills Bypass [which transverses a highly modified and poorly connected landscape] has the potential to enhance ecological objectives by functioning as a greenway. The connectivity concept could benefit the road development by providing guidance for the placement of new wetland patches and corridors where existing wetlands are affected by the proposal, and could also be used to identify the placement of the new drainage systems [which could follow the recommended corridors to provide linkage to patches] so that the adverse environmental effects are minimised.

Benefits for landscape and roading management derived from the connectivity concept include: helping prioritise the patches and corridors which require enhancement; providing a framework for which the adverse environmental effects caused by the roading network are mitigated; and enhancing the road so that it provides linkage to the surrounding landscape matrix.

The primary benefit of any application of the connectivity and greenway concepts to landscape management is the ability to restore connectivity throughout the landscape. Since connectivity is crucial to retaining ecological integrity, these concepts have enormous potential in the protection of biodiversity. Therefore, where these concepts are incorporated in road design, a better roading development in ecological terms should result.

Yet, this thesis finds that there is only limited potential for the greenway and connectivity concepts to influence road design [Chapter Three]. The importance of road safety tends to be an overriding factor in the design of roads. Factors which take precedence in the geometric design of roads, and which may not be influenced by greenway and connectivity concepts include: vertical and horizontal curvature; the lay out of intersections; the camber of the road; the number and width of traffic lanes; the central reservation; and shoulders. Though, it is possible to reshape the side-slopes [batters] so that the road blends in with the topography [Appendix 3]. This provides an opportunity for future planners using the greenway and connectivity concepts to influence road design, through ensuring that the batters are suitable for the inclusion of patches or corridors in the road reserve [that is, batters that are flat enough to accommodate vegetation]. Additionally, the greenway concept may influence the width of the designated road reserve, so that greenway objectives can be achieved within its boundaries. This would require the thorough consideration of both transportational and non-transportational needs of the road reserve throughout the road design, construction and management process.

Conversely, planting within the road reserve may be designed so that road safety is enhanced. This constitutes a potential opportunity in which future planners may counter the dominance of road safety requirements in the design of greenways, by planting vegetation corridors and patches which meet safety requirements at the same time as providing ecological functions.

The case study analysis in Chapter Five found that the potential use of roads as greenways [where ecological objectives are dominant] may be most relevant in landscapes which are highly modified and fragmented environments because well vegetated landscapes already contain sufficient connectivity outside of the road reserve. In addition, slower roads, and therefore urban environments [which are highly modified and fragmented] may be more favourable to greenways when safety factors, such as minimum sight distances from intersections, are taken into account. Therefore, this thesis identifies the enormous potential that the greenway concept has for countering the effects of landscape fragmentation and the associated building of roads in New Zealand. However, in order to successfully implement greenway roads in New Zealand, changes within the present landscape and roading management regimes are required.

RECOMMENDATIONS

A number of deficiencies and opportunities for improvement have been identified in this thesis regarding management of the landscape and roading networks. The following recommendations address the main deficiencies in relation to each case study.

- In order to adopt a consistent approach to the management of State Highway 54, Manawatu and Rangitikei District Councils should ensure that the controls used to manage the land use effects along State Highway 54 are consistent.
- Manawatu and Rangitikei District Councils should consult with Transit New Zealand to examine incorporating greenway objectives [eg. ecological, recreational, aesthetics] in road design.
- The Manawatu District Council should investigate incorporating an incentive and education package in its district plan to enable comprehensive and effective consultation between landowners so that RM Act requirements are reached.
- Manawatu and Rangitikei District Councils should investigate coordinating the management of the landscape which constitutes the view from Stormy Point Lookout.
- The Manawatu-Wanganui Regional Council should explore adopting a more ecosystem-based approach in it's Regional Policy Statement [such as that similar

to the Wellington Regional Policy Statement] for the integrated management of natural and physical resources.

- The Kapiti Coast District Council should investigate adopting the greenway concept, to ameliorate the adverse environmental effects of the Sandhills proposal, and also to aid prioritisation of the patches and corridors which require enhancement. For instance, this framework could be used to identify the locations of new wetlands, vegetation and drains associated with the road.
- The Kapiti Coast District Council should examine adopting a roading hierarchy for management of land use effects on the roading network.
- In regard to heritage registers, the Rangitikei and Kapiti Coast District Councils should examine the inclusion of landowners at the initial phase of patch identification, to reduce the risk of antipathetic attitudes towards private property conservation.
- Transit New Zealand should investigate including environmental concerns in it's objective so that a safe and efficient land transport system that maximises national economic, social *and environmental* benefits is achieved.
- The Department of Conservation should examine taking a leading advocacy role for the enhancement of New Zealand's roadsides where conservation objectives can be achieved.

ISSUES FOR FUTURE RESEARCH

ISSUES FOR SCIENCE

This thesis has highlighted a number of potential areas for future research in the science domain. The first and most pressing of these relates to the largely deficient state of ecological information on New Zealand's ecosystems. For instance, little is known about the general movement of wildlife through the New Zealand landscape. Therefore, research is needed on: the composition [in terms of animals and plant species], size and requirements [for instance, relating to survival needs] of patches and corridors in the New Zealand landscape; the interactions and processes between these landscape elements, for instance: wildlife requirements and movement patterns, and edge effects; and to improve the general understanding of the role of corridors and habitat patches in the conservation of native fauna and flora.

More specific to this thesis, research is required on the ecological characteristics and processes occurring in roadsides in New Zealand. This includes: which species are able to utilise these habitats and which species cannot; what kinds of resources are available to species on roadsides and how they are used; the dynamics of wildlife populations in roadside habitats and in the surrounding landscape matrix; and on the movements along road reserves and the attributes of the roadside environment [including: habitat quality, width, connectivity] that will optimise these movements. Both the general and specific research requirements outlined above are necessary for the future application of the greenway concept in New Zealand, so that management implications [for example, pest management] can be better understood and addressed.

ISSUES FOR PLANNING

This thesis reveals that the application of the greenway concept to roads may not always provide a connected network of patches and corridors due to the overriding factors relating to road safety. Consequently, future planners attempting to apply the greenway concept may have to consider opportunities other than the road reserve for the establishment of wildlife patches and corridors [Chapter Five]. Additionally, since roads cut across a variety of management regimes, planners will need to identify potential opportunities and constraints along the greenway which can provide for the establishment of new wildlife habitat.

There are many opportunities for the establishment of wildlife habitat in private property, including: presently unvegetated stream corridors for riparian enhancement, areas of steep topography which is prone to erosion, property boundaries, and golf courses. Industrial sites and institutions also provide ideal opportunities for the establishment of wildlife habitat. However, the present climate of privatisation and cuts in government funding in New Zealand may alter the degree to which large industries and institutions support wildlife habitat. In order to understand the implications for these activities [for instance: private land use, industry and institutions] becoming involved in greenway design, research is required which addresses these aspects. Additionally, research is required to increase understanding of the implications which may arise from conflicts between the differing uses in the road reserve.

As discussed in Chapter Five, several problems arose when the connectivity concept was applied to the case studies. Firstly, Fedorowick (1993) does not offer any assistance for deciding which part of the patch should be connected by the greenway corridor. However, this problem could be minimised through thorough and detailed assessment of the patches so that the most effective and appropriate connections can be made to that patch. This reinforces the importance of understanding the landscape context prior to siting greenways.

Secondly, there was difficulty in assigning the maximum diameter of each circle, and in some cases, it was hard not to include any patches and corridors in the centre of the connectivity circles. This problem could be reduced by ensuring that only the significant patches [for example, large patches] are used to establish the connectivity circles, though this may be difficult since the majority of the patches were small in all three of the case study areas.

A third problem arose from the one kilometre radius used to define the study areas, as this often excluded significant patches and corridors which could be viable connections. Therefore future applications of the concept should use a larger study area which incorporates all or the majority of significant patches in the vicinity of the road [for example, the study reach boundary could be established by inclusion of all significant patches] to reduce the likelihood of this problem occurring.

The greenways used in this thesis focus on the attainment of ecological objectives along the roading network. However, in order to gain a complete picture of the implications and applicability of greenway roads in New Zealand, further research on the incorporation of other greenway objectives [eg. recreation, aesthetics] in road management is required.

The greenway concept is still in its infancy in New Zealand. While this thesis offers a starting point as to how roads can be enhanced as greenways, additional research into the application of greenways to other components of the landscape, including: rivers and streams, ridgelines, and urban environments, would be helpful for providing a broader picture of greenway applicability in the New Zealand landscape. Therefore, if the greenway concept is to be pursued in New Zealand, planners and scientists will have to work together to identify these problems and develop joint solutions.

APPENDICES

LAND OWNERSHIP

One-third of New Zealand's land is protected as Crown-owned conservation areas. The other two-thirds of New Zealand's land is held in private ownership or is unprotected Crown land (Edwards and Sharp, 1990). However, many rare and valuable types of native forest, especially in lowland and coastal areas, are found as habitat patches on private land. Additionally, much of this private land contains modified habitats which may have high cultural significance. Protection of this private land is almost completely reliant on voluntary provision and initiative by the landowner (Ibid). Private landowners are generally not forced to protect land of high conservation value on their property. The voluntary provision is an important factor resulting in a large amount of private land worthy of conservation, not being protected for a number of reasons.

LANDOWNERSHIP ATTITUDES

Landownership becomes a potential impediment to nature conservation when there is indifference, or even antipathy towards nature protection. This is mainly explained in terms of the costs associated with conservation practices, especially those who allocate part of their holding to conservation (Cocklin, 1994). Edwards and Sharp (1990) identified three elements of costs involved in the conservation of private land. First, there are opportunity costs of foregoing the right to use the land without restriction. Second, there is the cost of negotiating an agreement specifying the rights and duties of parties to the transaction. The third element of cost is derived from the need to monitor and enforce the conservation agreement. The protection mechanism used will determine the magnitude of these costs.

Results of two surveys conducted around the Auckland region in 1991 and 1993, provide confirmation of two established generalisations relating to attitudes of landowners to nature conservation. Firstly, landowners believe strongly in their rights of dominion over their property. This reveals conflict between private property rights and the restrictions that conservation potentially places on land use. While many landowners are not fundamentally opposed to conservation, it is accorded a lower priority when it implies restrictions on other activities (Cocklin, 1994).

Secondly, landowners are not favourably disposed towards command-and-control planning mechanisms. Landowners indicate a preference for conservation mechanisms based on economic incentives and voluntary methods, as these reduce the cost of conservation (Cocklin, 1994). Therefore, landowner attitudes are extremely important in conservation, and may pose as an impediment to successful landscape protection.

RESOURCE MANAGEMENT ACT 1991

The Resource Management Act 1991 [RM Act] is the dominant body of environmental legislation in New Zealand. The resource management law reform which took place throughout the late 1980s and early 1990s repealed a plethora of environmental planning and management statutes. Included in this was the main planning statute: the Town and Country Planning Act 1977. This reform led to the enactment of the RM Act. (Memon and Gleeson, 1995). The RM Act differs from existing legislation in that it has a single, clear and overarching purpose: "to promote the sustainable management of natural and physical resources[1]" (Ministry for the Environment, 1991). Section 5 of the Act defines sustainable management as:

> "managing the use, development, and protection of natural and physical resources in a way, or at a rate, which enables people and communities to provide for their social, economic and cultural well-being and for their safety and health while -
> (a) Sustaining the potential of natural and physical resources (excluding minerals) to meet the reasonably foreseeable needs of future generations; and
> (b) Safeguarding the life-supporting capacity of air, water, soil and ecosystems; and
> (c) Avoiding, remedying or mitigating any adverse effects of activities on the environment." (Resource Management Act, 1995: 24).

A key feature of the RM Act is that emphasis is placed upon the 'effects' of activities, rather than of the activities themselves. The definition of effects is broad, and has incorporated a new requirement for the consideration of cumulative effects (Dixon, 1993). A hierarchy of plans and policy statements is outlined in the RM Act where each level is binding over those below them to the extent that they may not be inconsistent (Milne, 1996). This hierarchy is shown in Figure A3.4. The RM Act also requires local government to consider alternatives and assess the benefits and costs before adopting any objective, policy or rule [Section 32], which requires local government to look at a range of different techniques to achieve particular outcomes (Cutting, 1994).

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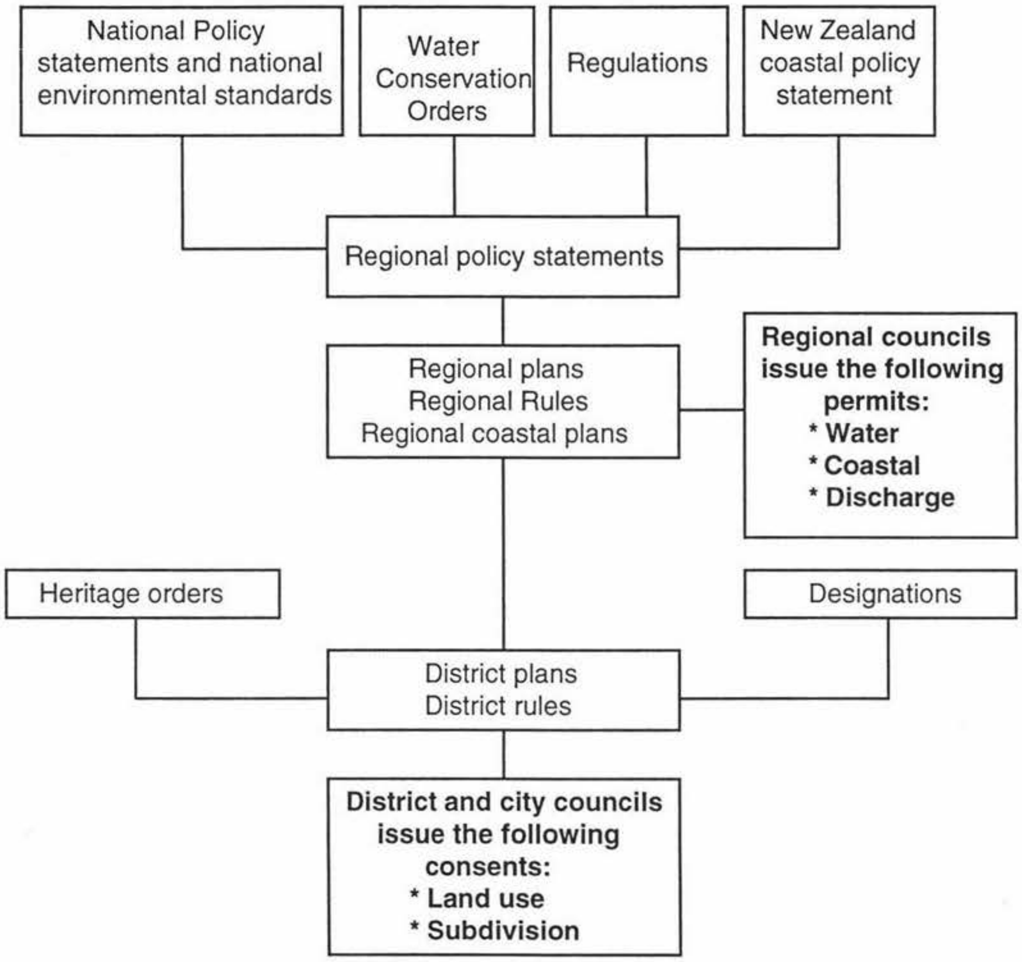
[1]Natural and physical resources are defined as "land, water, air, soil, minerals, and energy, all forms of plants and animals [whether native to New Zealand or introduced] and all structures" (Resource Management Act, 1995:16).

Figure A3.4 Hierarchy of Policy and Plans Under the Resource Management Act 1991 (Source: Milne, 1996:43)



Despite the fact that the term "landscape" is mentioned only a few times in the RM Act, landscape issues under this statute are important. This importance is derived from the obligations by the RM Act particularly in Sections 5, 6 and 7 [Part II], and key definitions of "environment" and "amenity" (Henderson and de Lambert, 1992). Under Section 6, certain principles must be "recognised and provided for" which clearly identify resource issues of national importance as a mandatory responsibility to achieve sustainability. Each resource issue identified in Section 6 is connected with, and contributes to the landscape (Ibid).

The landscape, according to Henderson and de Lambert (1992), is composed of physical [landform and feature], ecological [dynamic, natural] and cultural [induced change] components. A further component refers to the perception [value or importance] humans place on the landscape. Section 7 of the RM Act, provides a mandate for giving regard to the way in which resources are perceived. This section is less stringent than section 6, where "other matters" are outlined for people to "have particular regard to". Amenity values are important in this respect. The RM Act's definition of amenity values links natural and physical features to the perception component of landscape (Ibid). Amenity also comes within the definition of "environment" (Upton, 1996), reinforcing the importance of landscape values within the Act. The RM Act defines amenity values as:

> "those natural or physical qualities and characteristics of an area that contribute to people's appreciation of its pleasantness, aesthetic coherence, and cultural and recreational attributes" (Resource Management Act, 1995:9).

Methods for Achieving Conservation Under the Resource Management Act 1991

The Resource Management Act 1991 has a number of provisions that can be used to protect private and public land. Landscape protection methods vary depending on land ownership. Each method is outlined below and is summarised in Table A3.4. The methods are analysed according to four factors: the degree of interference each method has in the exercise of private property rights; who bears the costs of implementing each method; how can the method be used to achieve greenway objectives. To help demonstrate the usefulness of each method, Table A3.4 identifies which type of landscape element [patches or corridors] the method primarily protects. The most suitable methods for private property conservation and greenways will involve the least amount of interference in private property rights; low costs, or the provision of compensation to the landowner; and be able to achieve several greenway objectives.

District Plan Rules

Section 76 of the RM Act requires territorial authorities to include rules in their district plans which set out limits on the scale of effects that may occur in defined areas (Milne, 1996). Regional councils can also include rules in regional plans, which deal with issues at a regional level. The use of rules for landscape protection can interfere in the exercise of private property rights. Rules can impose high costs on the landowner, for example through the imposition of esplanade reserves upon subdivision. The implementation of rules for conservation may also damage landowner attitudes towards landscape protection. Rules force landowners

		Criteria for Analysis of Methods		
	Patch/Corridor	*Private Property*	*Who bears the costs*	*Greenway Objectives*
Methods		*rights interference*		
District Plan Rules	P, C	High	Landowner	All Objectives
Esplanade Reserves	C	High	Landowner, TA	PA, R, B, W,NH, DC, A,
Esplanade Strips	C	Moderate	Mostly landowner	PA, R, B, W, NH, DC, A
Heritage Orders	P,C	High	Mostly landowner	B, W, R, C, H, PA, E, Ex, A
Water Conservation Orders	C	High	Regional council, other	W, R, A, BD, E
Conservation Parks	P	High	DoC	B, W, C, H, R, A, PA, E,
Wilderness Areas	P	High	DoC	B, E, A, H
Ecological Areas	P	High	DoC	B, E, A, H
Sanctuary Areas	P	High	DoC	B, E, A, H
Watercourse Areas	C	High	DoC	A, R, BD, W, H
Marginal Strips	C	Moderate	DoC, landowners	W, PA, R, C, H, B, NH, A
National Parks	P	High	DoC	A, B, PA, R, C, H, E
Wildlife Sanctuaries	P	High	DoC, landowners	B, A, H
Wildlife Management Reserves	P	Moderate	DoC, landowners	B, PA, A, H
Wildlife Refuges	P	Moderate	DoC, landowners	B, PA, A, H
Protected Private Land Agreements	P	High	Landowners, DoC	B, H, A, E, PA
Conservation Covenants	P	Moderate	Landowners, DoC, LA	B, A, PA, E, R, H
Management Agreements	P	Moderate	Landowners	R, H, A, B, E, PA,
Reserves	P, C	Varies	DoC, LAs,	R, H, S, B, E, PA, W, DC, A
Open Space Covenants	P	Moderate	Landowners, QEII Trust	B, A, PA, E, R, H
Forest Heritage Fund [FHF]	P, C	Varies	Landowners, FHF	B, W

Legend:

A	Amenity
BD	Biodiversity
C	Corridor
C	Culture
DoC	Department of Conservation
DC	Development Control
E	Education
Ex	Expression
H	History
LA	Local Authorities
NH	Natural Hazards
P	Patch
PA	Public Access
PS	Public Safety
QEII	Queen Elizabeth the Second National Trust
R	Recreation
TA	Territorial Authority
W	Water

Table A3.4 Methods Available for Landscape Protection Under Resource Management Act 1991 and Statutes Administered by DoC to implement protective mechanisms, allowing only limited involvement in the decision-making process for the landowner. This may leave the landowner feeling powerless, and hence antagonistic towards rules. Despite these disadvantages, rules are a valuable method for attaining a variety of greenway objectives, and can be used to protect both patches and corridors.

Esplanade Reserves and Esplanade Strips

Under the RM Act, "esplanade reserves" or "esplanade strips" may be vested in the territorial authority when land adjacent to the sea, or along banks of a river or a lake is being subdivided (Milne, 1996). The requirement for these esplanade provisions is based upon the presumptions of: where an allotment of less than four hectares in area is created, then a 20 metre esplanade reserve is obligatory beside that allotment. For allotments over four hectares no esplanade reserve or strip is required. These may be implemented through the use of rules in city and district plans, which can alter these presumptions. They can also be gifted or otherwise agreed to without any subdivision. Esplanade reserves are reserves under the Reserves Act 1977 alongside water bodies which is surveyed off and vested in the territorial authority on subdivision (Ministry for the Environment, 1993). Their purpose is threefold: conservation, public access and/or compatible recreational use (New Zealand Institute of Surveyors, et al. 1993). The conservation purpose includes: the maintenance or enhancement of the natural functioning of the adjacent sea, river or lake; maintenance or enhancement of water quality or aquatic habitats; and the protection of natural values or mitigation of natural hazards (Milne, 1996).

The purpose of esplanade reserves also applies to "esplanade strips", defined as a strip of land alongside water bodies and/or the bed of a water body (Ministry for the Environment, 1993). The distinguishing features of an esplanade strip are that: the land remains in private ownership; it does not necessarily need to be a surveyed area; it moves with the edge of the sea, lake or river so that if that edge moves so does the landward edge of the strip in parallel (Royal Forest and Bird Protection Society of New Zealand, 1995). Territorial authorities must provide in their district plans when a strip is to be provided instead of a reserve (Milne, 1996). DoC (1993a) has identified when esplanade strips and esplanade reserves should be employed. An esplanade strip should be employed when the primary objective is the provision of continuous access. Esplanade reserves, on the other hand, should be implemented when both access/recreation and conservation values are of exceptional importance.

As the land remains in private ownership and surveying is not required, the esplanade strip may be a less expensive method for landowners. Esplanade strips allow access and the protection of conservation values, while safeguarding the rights of landowners (New Zealand Institute of Surveyors, 1993). Still, the cost of implementing these mechanisms is not imposed solely on the landowner. The territorial authority involved may accept some responsibility for an initial contribution of finance or resources, though for these authorities, this outlay is not likely to be as onerous as for an esplanade reserve, since the landowner retains responsibility for the day-to-day management of the area (New Zealand Institute of Surveyors, 1993). In contrast, the territorial authority inherits responsibility for management of the esplanade reserve, which may have implications for ongoing maintenance costs. Territorial authorities must also provide landowner compensation under the RM Act when requiring esplanade reserves.

Mosley (1996) believes the benefits of these riparian management mechanisms are not obvious to many. At first they are simply viewed as a means of taking valuable land out of production. Many landowners may be skeptical of esplanade provisions due to the restrictions they impose on the existing use of land. However, esplanade reserves or strips provide many benefits to landowners by primarily creating a buffering effect on the local water body (Kapiti Coast District Council, 1993b).

Esplanade reserves and strips hold significant potential for greenway planning. The characteristic form of reserves and strips alongside water bodies provides a mechanism to protect landscape corridors. The protection of these corridors in turn provides linkage to other elements contained along the greenway. Additionally, the potential multipurpose focus of esplanade provisions, where conservation values are protected while still enabling recreation and public access, is also important for greenway management. One of the greatest impediments to these provisions, however, may be landowner attitudes towards the restrictions placed on their land when vested in esplanade reserves or strips. The esplanade strip may therefore present the most viable option as although it places restrictions on the use of land and can allow public access, the land remains in private ownership and can continue to be used by the landowner.

Heritage Orders

The RM Act provides for "heritage orders'" as a means to protect a variety of significant sites and features. They can be used to designate a place of special interest [by virtue of special cultural, architectural, historical, scientific, ecological or other interest], character, intrinsic or amenity value or visual appeal, or cultural, historical or spiritual significance, and any area surrounding the place, to ensure its protection and enjoyment (Milne, 1996). This wide-ranging purpose is therefore applicable to the greenway concept, in that orders could be used to achieve one of many greenway objectives outlined in Table A3.4. In addition, the protection they accord is fully integrated into all aspects of resource management, in that they become part of a district or regional plan and operate like a rule (Milne, 1996). Only "heritage protection authorities" [for example: Ministers of the Crown, local authorities, the New Zealand Heritage Places Trust, or other interest groups which satisfy certain criteria] are eligible to apply for a heritage order.

This method of conservation can impose large costs on the landowner. Once confirmed, the order can be used to stop what would otherwise be a lawful activity. Therefore, the landowner may be prevented from conducting normal land use practices. Other costs include those expenses of upkeep incurred as a result of the order, though the relevant territorial authority can make a recommendation that the heritage protection authority pay the landowner for these costs (Milne, 1996). In certain cases [for example: where the order will render the land incapable of reasonable use], the Planning Tribunal can order the heritage protection authority to pay for acquisition of the land. In this case, the costs are imposed on the heritage protection authority.

Heritage orders could be used to protect "patches" and "corridors" of significant value while assuring enjoyment to the public along a greenway. The costs of implementing heritage orders may reduce their popularity, in that they may impose austere restrictions on the landowner's use of land. On the other hand, if the heritage protection authority purchases the land, the cost of this exercise may prove very expensive and well beyond the means of most interest groups acting as heritage protection authorities.

Water Conservation Orders

The RM Act provides for "water conservation orders" which have the purpose of recognising and sustaining water bodies of outstanding natural, amenity or intrinsic value (Ministry for the Environment, 1991). An order may contain restrictions as to flow, level, contaminant content or temperature. The key criterion in deciding if water is eligible for a water conservation order is whether or not it is "outstanding".

While not defined in the RM Act, "outstanding" has been taken to mean "equivalent to national importance" or "prominent compared to others of its kind". Therefore, waters which are only locally or regionally significant are most appropriately protected through rules in regional policies and plans (Milne, 1996).

Water conservation orders protect the water not only in "corridors" of rivers and streams, but in "patches" containing lakes, groundwater aquifers, geothermal waters, ponds and wetlands. However, a water conservation order only protects *water*. If the water body is included in a more extensive ecosystem requiring protection, then a heritage order, which can be used to protect all its constituent parts [for example: water, soil, plants, animals] may be a more suitable method for the greenway (Milne, 1996). On public land, a watercourse area [discussed later] could also be created. Water conservation orders are also expensive to implement and are therefore restricted to organisations with the financial resources to meet the costs of applications and the subsequent appeals (Milne, 1996).

CONSERVATION ACT 1987

The Conservation Act 1987 promotes the conservation of New Zealand's natural and historic resources. The Department of Conservation [DoC] was established under the Conservation Act 1987, this defining two primary functions for the Department. First, to manage all natural and historical resources allocated to it for conservation purposes. Second, to advocate and promote the conservation of natural and historical resources, and to allow and foster use of these resources for recreation and tourism, consistent with its conservation priorities (Memon, 1993). DoC administers a number of statutes which are important for the protection of public and private land. These statutes include the: Conservation Act 1987, Reserves Act 1977, National Parks Act 1980, Wildlife Act 1953, New Zealand Walkways Act 1990, Wild Animal Control Act 1977, Marine Mammals Protection Act 1978, and Marine Reserves Act 1971 (Milne, 1996).

DoC establishes management guidelines for the administration of all land which is managed under the provisions of the Conservation Act 1987 and other Acts administered by the Minister of Conservation, through Conservation Management Strategy [CMS's] and Conservation Management Plans [CMPs] (Rosier, 1993). The purpose of a CMS is to "implement general policies and establish objectives for the integrated management of natural and historic resources, including any species, managed by the Department...and for recreation, tourism and other conservation purposes" (Department of Conservation, 1993b). At present there are no general policies for protected areas or natural and historic resources, except for national parks (Milne, 1996). All protected species are included in the CMS, whether they occupy public, private or leasehold land. The management of conservation methods such as covenants, protected private land and wildlife refuges, on private and leasehold land is also covered by the CMS (Department of Conservation, 1993b).

Under the CMS umbrella, Conservation Management Plans [CMPs] set detailed objectives for integrated management within any area or areas specified in a CMS. These CMPs must be consistent with the relevant CMS (Department of Conservation, 1993b). CMPs are prepared only where it is necessary to provide management direction, resolve major conflicts, or when special management circumstances require it (Rosier, 1993). As part of the integrative framework established under the RM Act, Section 74 of this Act requires territorial authorities to "have regard to" these management plans and strategies when preparing their district plans. Regional councils must also "have regard to" these documents when preparing their regional plans [Section 66] and policy statements [Section 61]. This is shown in Figure 3.1 [Chapter Three].

Regarding implementation of a greenway system in New Zealand, the CMS could be used to provide general objectives for integrated management for the greenway within the conservancy. However, DoC would need to prepare general policies for the integration of natural and historic resource management. A CMP would then establish specified management objectives for each of the patches and corridors along the greenway. Greenways are characteristically a mixture of public and private resource ownership. The ability of the CMS to integrate the management of both public, private and leasehold resources presents itself as a valuable coordinating tool for greenway planning. Therefore, the use of a CMS [and associated CMPs] could provide policy and guidance for implementation of a greenway system in New Zealand.

Methods for Achieving Conservation Under Statutes Administered by DoC and Others

"Conservation areas" is a generic term for all land protected under the Conservation Act 1987. This Act defines three categories of publicly owned conservation area: specially protected areas, marginal strips and stewardship land. Land requiring special protection or preservation can be declared as "specially protected areas" which includes: conservation parks, wilderness areas, ecological areas, sanctuary areas or watercourse areas. "Stewardship land" is managed to protect the natural and historic resources. More than a third of New Zealand's public conservation lands are stewardship land, yet there has been little effort by DoC to identify conservation values on these lands and provide them with greater protection under the Conservation, Reserves or National Parks Acts (Milne, 1996). DoC is responsible for the costs of implementation and maintenance of specially protected areas and marginal strips. Table A3.4 outlines each of these methods and analyses the extent to which they could be used in a greenway network.

Conservation Parks

"Conservation parks" are a type of specially protected area which have the purpose of protecting each area's natural and historic resources and to facilitate public recreation and enjoyment (Rosier, 1993). Conservation parks may include any other type of specially protected area (Milne, 1996). These parks could be used to protect large patches of publicly owned land within a greenway network. Several greenway objectives could be achieved through the creation of conservation parks, such as: the protection, management and enhancement of biodiversity; water resources, historic and cultural resources, and the provision of opportunities for recreation.

Wilderness Areas, Ecological Areas, Sanctuary Areas

"Wilderness areas" are managed to preserve indigenous natural resources that are unaffected by human activities, and as such are subject to provisions which prohibit buildings, tracks, vehicles, mining and other development. "Ecological areas" are managed to protect representative ecosystems. "Sanctuary areas" preserve special natural areas in their natural state for scientific and other purposes (Milne, 1996; Rosier, 1993). These methods are "specially protected areas" which have similar objectives in that they are used generally to protect or preserve biodiversity. Each of these methods could be employed to help achieve the greenway objective relating to biodiversity in habitat patches within the greenway.

Watercourse Areas

"Watercourse areas" are a type of specially protected area, managed to protect the outstanding wild, scenic or other natural or recreational characteristics of adjoining water bodies protected by a water conservation order. Watercourse areas could be used to achieve the greenway objectives relating to water along greenway corridors.

Marginal Strips

"Marginal strips" are situated alongside the seashore, lakes and rivers. They are employed for the conservation of natural and historic resources, or the provision of public access or recreation to adjacent water. Marginal strips are very much like esplanade reserves except that their origins are in the disposal of Crown land rather than subdivision of private land (Milne, 1996). Adjoining landowners may be appointed as managers of these strips by the Minister of Conservation. The manager is required to comply with any Ministerial requirements or restrictions to maintain access to and recreational use of the strip. Marginal strips can therefore be used to protect significant corridors along the greenway network. This method could help achieve greenway objectives relating to water resources, public access, recreation, cultural and historic resources and biodiversity.

National Parks

The National Parks Act 1980 creates "national parks" which protect patches of land in perpetuity that contain scenic, ecological, and natural features which are so beautiful, unique or scientifically important that their protection is of interest nationally. Each national park is managed by a management plan which control how they are protected, used and developed. Uses can be controlled by the classification of parts of national parks as wilderness areas, specially protected areas and amenities areas (Milne, 1996).

National parks in America share many of the characteristics of greenways, including: a combination of public and private resource ownership; shared management responsibilities; diverse resource values within the area to be protected - natural, cultural and recreational; and usually linearity (Zube, 1995). While national parks in New Zealand incorporate diverse resource values, their management is principally conducted through DoC; they are owned solely by the Crown; and are often found on mountains or mountain ranges [therefore tending not to be linear]. Despite these inconsistencies, national parks in New Zealand could be used to protect large significant patches of public land within a greenway network, while attaining greenway objectives relating to: amenity, biodiversity, science, education and recreation.

Wildlife Sanctuaries, Management Reserves, and Refuges

The Wildlife Act 1953 establishes three types of protective mechanisms for landscape patches. "Wildlife sanctuaries" automatically protect all patches of wildlife. Public access in these sanctuaries is usually restricted (Milne, 1996). "Wildlife management reserves" provide a similar protection to wildlife sanctuaries, except protection is not automatic. Where public access is contemplated, this method is preferred over wildlife sanctuaries (Milne, 1996). "Wildlife refuges" are the lowest category of protection under the Wildlife Act 1953. Refuges are similar to sanctuaries except that the focus is on species management rather than habitat management (Rosier, 1993). Refuges can be an inadequate mechanism for wildlife protection as they do not bind subsequent owners, habitat protection relies on the goodwill of the landowner, and they offer only limited protection for wildlife habitat. While DoC manages these areas, compensation is available to landowners who are prepared to protect wildlife on their land, through rating relief under the Rating Powers Act 1988. The private landowner faces restrictive land use when these methods are established.

Wildlife management reserves prove to be the most useful greenway method for the protection of habitat patches under the Wildlife Act. By establishing wildlife management reserves, greenway objectives relating to biodiversity and public access can be attained. However, in cases where wildlife values require more absolute protection, wildlife sanctuaries could be established for the fulfillment of greenway objectives, such as biodiversity.

Protected Private Land Agreements

"Protected private land agreements", prepared under the provisions of the Reserves Act 1977, award reserve status on private patches of land so that it may be managed as a scenic, historic, scientific or nature reserve. Protection is effected through a voluntary agreement between the landowner and the Minister of Conservation. The land is then declared "protected private land" and the agreement is registered on the title (Milne, 1996).

Where DoC is unable to do so, responsibility falls on the landowner to protect these areas. Financial assistance can be provided by DoC in the form of fencing, or rating relief under the Rating Powers Act 1988. No activities are permitted unless they are necessary for the proper management of the land, such action is provided for in a management plan, or written approval is sought from the Minister of Conservation

(Milne, 1996). This type of method is therefore highly restrictive on the landowner. However, protected private land agreements could be used to achieve greenway objectives for the protection of patches in regard to biodiversity, historic resources, amenity and educational resources.

Conservation Covenants

"Conservation covenants" are provided for in the Conservation Act 1987 and Reserves Act 1977. A covenant is a voluntary contract between a private landowner and an agent of the state. Conservation covenants can be negotiated over private property to preserve in perpetuity the natural environment, including landscape amenity or habitat (Milne, 1996; Rosier, 1993). The landowner who enters into a covenant can use the relevant land subject to restrictions imposed, and can sell or otherwise dispose of the land (Edwards and Sharp, 1990). The covenant is usually registered against the title of land, and is therefore binding on future owners.

Conservation covenants are administered by DoC, local authorities or any other approved agency, which become the legal beneficiary of the covenant with the responsibility of enforcing conditions (Edwards and Sharp, 1990). The cost of setting up the covenant can be distributed between the administrating body and landowner. The landowner faces restrictive usage of the land, however, the Department may contribute to land management [for example fencing or replanting], and is also responsible for maintenance and monitoring of the covenant.

Conservation covenants therefore provide an effective mechanism for protecting patches of habitat on private land. Covenants could be used to help achieve the greenway objectives relating to biodiversity and amenity in patches. They also attempt to address the issue of landowner attitudes towards nature protection by providing incentives for landowners.

Management Agreements

"Management agreements" are voluntary agreements or contracts between the landowner and the Minister of Conservation to manage conservation values [such as: recreation, historic, scenic, nature or scientific] in patches on private land. However, management agreements are the lowest form of protection for private land offered under the Reserves Act 1977 and Conservation Act 1987. These agreements may be for any length of time, do not bind future owners, and do not provide reserve status protection under the Reserves Act (Milne, 1996). The Minister may contribute to land management on the property, while rating relief under the Rating Powers Act 1988 is available to landowners who enter into a management agreement.

Management agreements pose as a more flexible, albeit lower protecting conservation method for private landowners. When dealing with landowners who do not want to enter into a conservation covenant or declare their land as protected private land, or with areas of land which do not require such stringent protection measures, this method may be useful for protecting private patches within a greenway. However, the implementation of this method relies upon the willingness of the landowner to have the land protected. This also applies to protected private land agreements and conservation covenants.

Reserves

"Reserves" available under the Reserves Act 1977, protect and manage patches or corridors of land held in public ownership for purposes including: recreation, historic, scenic, nature and science. Each reserve may be classified as a national or local reserve for management purposes (Milne, 1996). The Minister of Conservation can appoint administering bodies for reserves who are required to prepare management plans. All reserves managed by DoC are subject to general policies, the CMS and CMPs (Ibid). No activities can take place on reserved land unless such action is provided for in a management plan, the administering body considers it necessary for the proper management of the reserve, or written approval is received from the Minister of Conservation (Ibid). Depending on the purpose of the reserve, greenway objectives for patches of land [or significant corridors in the case of esplanade reserves] can be achieved through reserve classification. For instance, objectives relating to public access, recreation, amenity, scientific, educational and ecology, can be protected through reserve provisions.

Queen Elizabeth the Second National Trust Act 1977

The Queen Elizabeth the Second National Trust Act 1977 provides for "open space covenants" which are intended for the maintenance of open space on private land and the benefit and enjoyment of people (Mason, 1994). Open space covenants are administered under the Queen Elizabeth the Second National Trust. The Trust is an independent conservation body, funded principally by central government. Once the covenant is entered into, the Trust becomes the legal beneficiary of the covenant and is entrusted with the responsibility of enforcing its conditions (Edwards and Sharp, 1994). As with conservation covenants, open space covenants are registered on the property's title, thereby binding future owners (Milne, 1996).

The landowner faces restrictions on the use of the subject land, though compensation in the form of rating relief is available through the Rating Powers Act 1988. In setting up the covenant, the Trust is responsible for surveying, the provision of public access and associated facilities, and provides some financial assistance to the landowner for fencing. Responsibility for monitoring and enforcement of the covenant also falls on the Trust. As with conservation covenants, open space covenants administered under the Trust represent a potentially valuable mechanism for protecting significant patches on private land.

Forest Heritage Fund

Financial assistance is available to landowners who wish to protect indigenous forest on their land, through the "Forest Heritage Fund". The Fund is a government scheme which protects privately owned forests of high ecological value through: voluntary agreements or covenants; land purchase; the creation of reserves, or additions to existing reserves; accords and land exchange. For example, the Fund can help with the survey, fencing, and legal expenses associated with covenants (Sage, 1992). As landowners prefer conservation mechanisms based on economic incentives and voluntary methods, the Fund represents a viable mechanism for encouraging the private landowner to protect patches of forested land of significant conservation value.

Land Acquisition Fund

The Department of Conservation's "Land Acquisition Fund" can be used to financially aid the private landowner in conservation. This Fund purchases land with high conservation values from private landowners, state-owned enterprises and other government departments. The Fund is aimed at non-forested patches of land as purchases of forested land are funded through the Forest Heritage Fund (Milne, 1996).

APPENDIX 2: DEFINITION OF ROAD, LOCAL GOVERNMENT ACT 1974

SECTION 315

"Road" means the whole of any land which is within a district, and which:

(a) Immediately before the commencement of this Part of this Act was a road or street or public highway; or

(b) Immediately before the inclusion of any area in the district was a public highway within that area; or

(c) Is laid out by the council as a road or street after the commencement of this Part of this Act; or

(d) Is vested in the council for the purpose of a road as shown on a deposited survey plan; or

(e) Is vested in the council as a road or street pursuant to any other enactment; and includes:

(f) Except where elsewhere provided in this Part of this Act, any access way or service land which before the commencement of this Part of this Act was under the control of any council [[or is laid out or constructed by or vested in any council as an access way or service lane]] or is declared...by the Minister of Works and Development as an access way or service lane after the commencement of this Part of this Act [[or is declared by the Minister of Lands as an access way or service lane on or after the 1st day of April 1988]]:

(g) Every square or place intended for use of the public generally, and every bridge, culvert, drain, ford, gate, building, or other thing belonging thereto or lying upon the line or within the limits thereof; but, except as provided in [[the Public Works Act 1981]] or in any regulations under that Act, does not include a motorway within the meaning of that Act.

ROAD DESIGN GEOMETRY

Due to a mostly unsuccessful search for Transit New Zealand guidelines, the design features discussed by O'Flaherty (1975) are used. As outlined in Chapter Three, the only New Zealand design standards available for analysing how road design influences the use of roads as greenways relate to the minimum sight distances at intersections. Therefore, implications of the following design features on maximising the use of roads as greenways will not be considered in this thesis, however, it is recognised that they will still play an important role in influencing road design.

Design Speed

The choice of the design speed helps determine the design of geometric features such as horizontal and vertical curvature, safe stopping and passing sight distances, and acceptable road grades. The main elements which affect the choice of design speed include: the type of road; the terrain through which it will operate; traffic characteristics; cost of land; speed capabilities of vehicles; and aesthetic features (O'Flaherty, 1975).

Sight Distances

Sight distance, which is defined as "the length of the carriageway that is visible to the driver" is one of the most important features in the safe and efficient operation of a road (O'Flaherty, 1975). According to O'Flaherty (1975), the geometric design of the road should ensure that at all times vehicles are visible to each other within normal eyesight distance. However, this is often not economically possible due to topographical and other considerations. Therefore, roads must be designed on the basis of sight distances that are the minimum necessary for the safety of drivers (Ibid). Two types of sight distance must considered: the "safe stopping sight distance" where sufficient sight distance must always be available to drivers to enable them to stop their vehicles prior to hitting an unexpected object on the carriageway; and the " safe passing sight distance" where adequate sight distance must be provided for drivers to overtake and pass slower vehicles in complete safety.

Horizontal Curvature

The safe and efficient design of roads is influenced by the horizontal curvature design. Curve design is an important factor in road safety since accident statistics reveal that the sharper the curve the greater the tendency for accidents to occur (O'Flaherty, 1975). The maximum comfortable speed on a horizontal curve is primarily dependent on the radius of the curve and the superelevation of the carriageway. This latter factor is used to provide resistance to the outward-acting centrifugal force. In some instances, radius of curvature may not be sufficient to ensure that the minimum safe stopping sight distance requirements are met. This may necessitate setting back the slopes of cuttings, fences, buildings or other obstructions adjacent to the carriageway. If these obstructs are immovable, the road alignment may need to be redesigned (Ibid).

Transition curves must be included in the design of significant horizontal curves. The primary purpose of transition curves is to allow vehicles moving at high speeds to make the change from the straight section to the curved section to the straight section of a road in a safe and comfortable way. Transition curves minimise the problems of vehicles moving onto the wrong lanes when entering or leaving a curve. They also encourage uniformity in speed, and increase vehicle safety at the curve (Ibid).

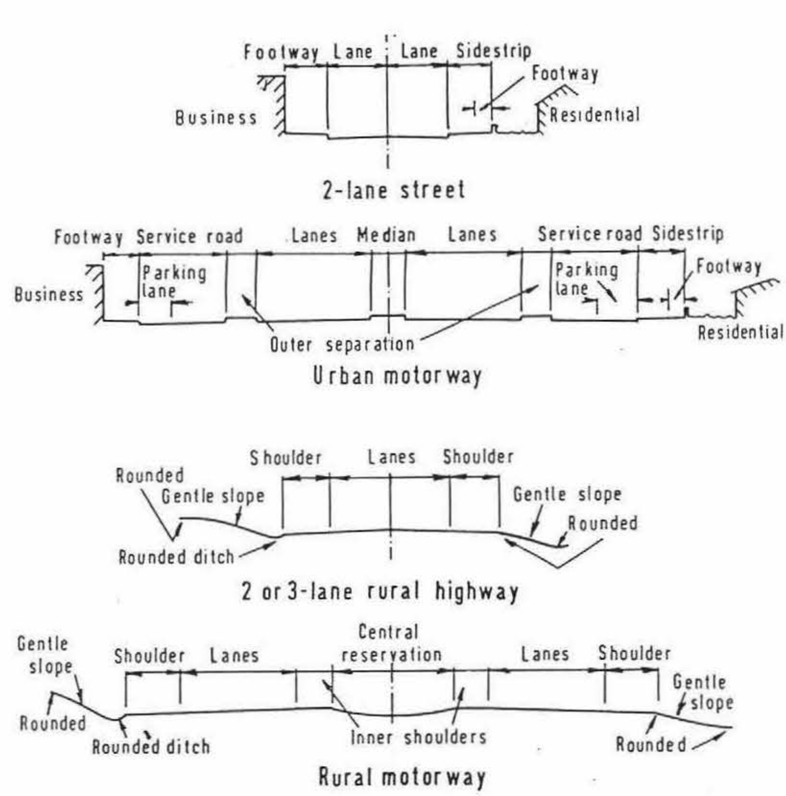
Vertical Alignment

O'Flaherty (1975:258) defines vertical alignment as "the design of tangents and curves along the profile of the road". The principal aim of vertical alignment design is to ensure that a continuously unfolding strip of road is presented to the motorist so that the anticipation of directional change and future action is instantaneous and correct (Ibid). The design of the vertical alignment must make sure that the minimum stopping sight distance requirements are met. Additionally, long stretches of steep gradients should be avoided due to their adverse effect on speeds, road capacity and safety. Where the uphill grade is extremely long, a passing lane is often required so that climbing slower-moving vehicles do not hold up faster vehicles.

Cross-Section Elements

Cross-section elements are "those features of the road which form its effective width and which affect vehicle movement" (Ibid, 1975:269). These include: the number and width of traffic lanes; the central reservation; shoulders; camber of the carriageway; and the side slopes of cuttings or embankments [batters]. Figure A3.5 shows the cross-section elements typical of two, three and four lane roads. The number of traffic lanes required is dependent on the volume and type of traffic that the road has to support. Obviously, early consideration of the non transportational and transportational uses of the road can provide for a wider road reserve in the design stage so that greenway objectives can be achieved. Central reservations have been proven to reduce the number of head-on collisions (Ibid, 1975). They are mostly required on roads which carry high volumes of traffic. Where planted with shrubs, central reservations can provide an aesthetically pleasing environment while reducing headlight glare and acting as crash barriers. Planted central reservations must not reduce the required sight distance at intersections.

Figure A3.5 Typical Highway Cross-Sections (Source: O'Flaherty, 1974:271)



Shoulders comprise the part of roadway which is adjacent to the carriageway that is used principally by parked vehicles (Ibid, 1975:272). Shoulders are required on all rural, and where possible, surburban arterial roads which carry large amounts of high-speed traffic. The width of shoulders on major highways is recommended to be three metres. As an alternative to shoulders, lay-bys can be used at appropriate locations along the road. These must be placed where sight distances from their exit and entry points are inadequate for safety.

Camber is described as the convexity of the carriageway cross-section (Ibid, 1975:273). The principal aim of cambering is to drain water and avoid ponding on the road surface. Camber design on two-lane roads will require the centre of the road to be very flat while the desired cross-slope will be exceeded towards the outside. On roads with three or more lanes, the camber entail a curved crown section for the central lane or lanes and a tangent plane section on each of the outer lanes. The cross-slope on the tangent planes is made the same or slightly steeper than that at the end of the curved section so that the accumulated water is removed easier (Ibid, 1975).

The final component of cross-section elements refers to the side-slopes of cuttings or embankments [batters]. For both safety and maintenance reasons, the flatter the side-slopes the better. For example, vehicles driving on to flatter slopes can be more easily brought under control, and flatter slopes also increase the horizontal sight distance at curves. Additionally, the flatter the side-slopes, the easier it is to grow grass on them, thereby reducing the chance of erosion. Maintenance can also be conducted much easier on flatter side-slopes.

Intersections

Intersections greatly influence vehicle safety and the efficiency of movement along roads. There are two primary types of intersections: at-grade [single-level], and grade-separated [fly-over] intersections. At-grade intersections can either be channelized or non-channelized. Channelization is used where two or more traffic streams are separated, each stream being confined to a single roadway channel. This enables safe movement of traffic. Roundabout intersections are considered as a form of channelized intersection. Non-channelized intersections may be either plain or flared. Although plain non-channelized intersections are the least expensive, they tend to be the most dangerous and inefficient, as no provision is made for turning or straight-through movement. Flared non-channelized intersections reduce the number and severity of accidents through the addition of a third lane.

Grade-separated intersections are advantageous in the following circumstances: at intersections on motorways; where existing traffic bottlenecks need to be eliminated; at at-grade intersections which are prone to accidents; where at-grade intersections cause traffic delays [these delays may incur economic losses associated with fuel use, tyres, oil, repairs and accidents]; and where topographical constraints or the cost of land may result in at-grade intersections being more expensive to construct.

OTHER ROAD DESIGN PRINCIPLES

Further considerations in road design include providing an aesthetically pleasing picture to both the driver and passenger (O'Flaherty, 1975). The aim of road design should be to ensure that the road is integrated with the total landscape and not an imposition (Laws, 1987). Therefore, the road should be aligned so it blends in with the topography. Thus, where straight roads pass through undulating landscape, the road should be aligned to the topography as closely as possible by using "fill" to supplement the existing topography and minimising "cut" by accepting suitable gradients (Hackett, 1971:60). Otherwise, the road will leave an ugly scar on the landscape. Figure A3.6 provides examples of how geometric design can be integrated with the topography and natural features. Figure A3.7 shows how the road can be linked with remnant patches.

Figure A3.6 Techniques to Integrate Geometric Road Design and Topography (Source: Laws, 1987:24-25)

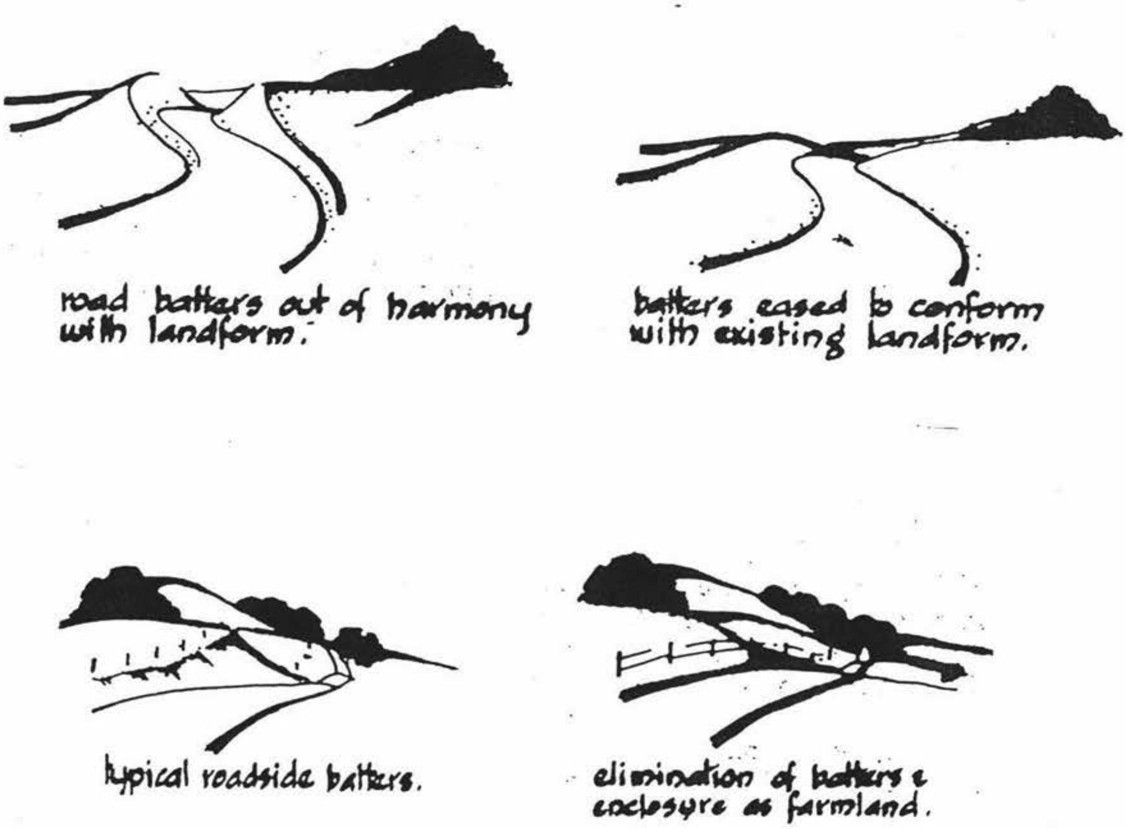


Figure A3.7 The Use of Planting to Enhance Linkage Between Patches Along the Roadside (Source: Laws, 1987:27)

The design principle of providing an aesthetically pleasing landscape was important in the implementation of the "Beautiful New Zealand Scheme" [Chapter One]. Implementers of this scheme were guided by several design principles in which the road and roadside planting could become integrated. The principles relevant to this thesis are listed as follows:

- The road should be subservient to and become part of the scenery through which it passes...Planting should always be designed with this principle in mind, so that the road becomes interlocked with the landscape. Views are as important as planting, so good views should be kept and mediocre ones framed, enhanced or dramatised by planting. Figure A3.8 reveals how trees can be used to frame desirable views.

Figure A3.8 The Use of Planting to Frame Views in Road Design (Source: Laws, 1987:26)

- Roadside planting should help to accentuate the "grain" of the landscape through which the road passes. A road will either follow the grain, as when if follows a valley line or a ridge line [Figure A3.9A] or it will cut across the grain [Figure

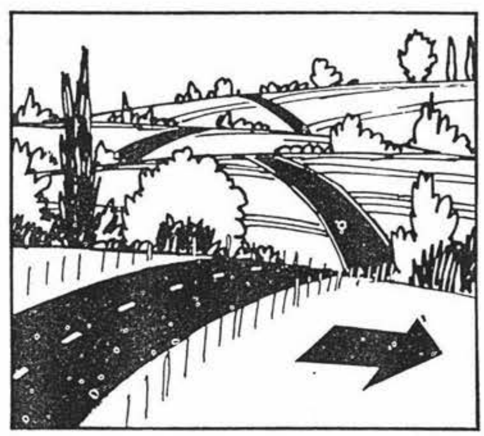
A3.9B]. In a flat landscape the grain will express itself in rivers and streams and by subtle changes in the soil types and consequent vegetation patterns.

- When the road flows with the grain, linear planting would generally be most appropriate either on one or both sides of the road or alternating sides, depending on views, existing planting and constraints caused by powerlines [Figure A3.9A]. When the road cuts across the grain, planting continuity across the road line would generally be most appropriate. Planting would therefore be designed to line up with shelter belts, reserves and stands of native bush, farm woodlots, soil stabilisation planting, planting along water courses and carry the line of these across roads [Figure A3.9B] (Ministry of Works & Development, 1984: 4).

Figures A3.9 Techniques In Which Roadside Planting Can Enhance Landscape Grain (Source: Ministry of Works and Development, 1984:4)

Figure A3.9A Road Follows Landscape Grain

Figure A3.9B Road Flows Against Landscape Grain



The design of planting can influence road safety. Figures A3.10A-C shows when vegetation can be used to enhance road safety.

- Vehicles leaving the road can be brought into control by the planting of bushy shrubs, shown in Figure A3.10A. The vegetation will slow down the vehicles without causing damage to the vehicle or motorist;
- To guide traffic by indicating the need for turning movements of vehicles, as around curves and intersections, that is, planting to make the road read [Figure A3.10B]

- Planting can also be used to focus attention on the road and reduce car speed by the sense of enclosure, as revealed in Figure A3.10C;
- Roadside planting can be used to control soil erosion and to break the wind in exposed areas, which in turn helps to control road hazards and therefore road safety.

Figures A3.10 The Use of Planting To Enhance Road Safety
(Source: Laws, 1987:27-28)

Figure A3.10A The Use of Vegetation as a Safety Buffer

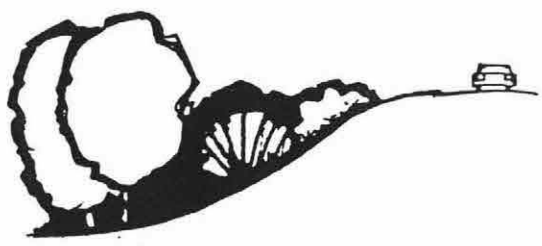


Figure A3.10B The Use of Vegetation to Guide Vehicles

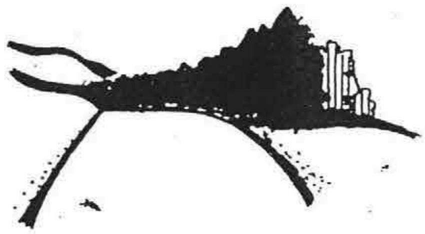
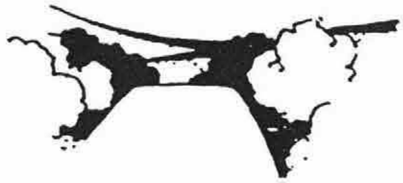
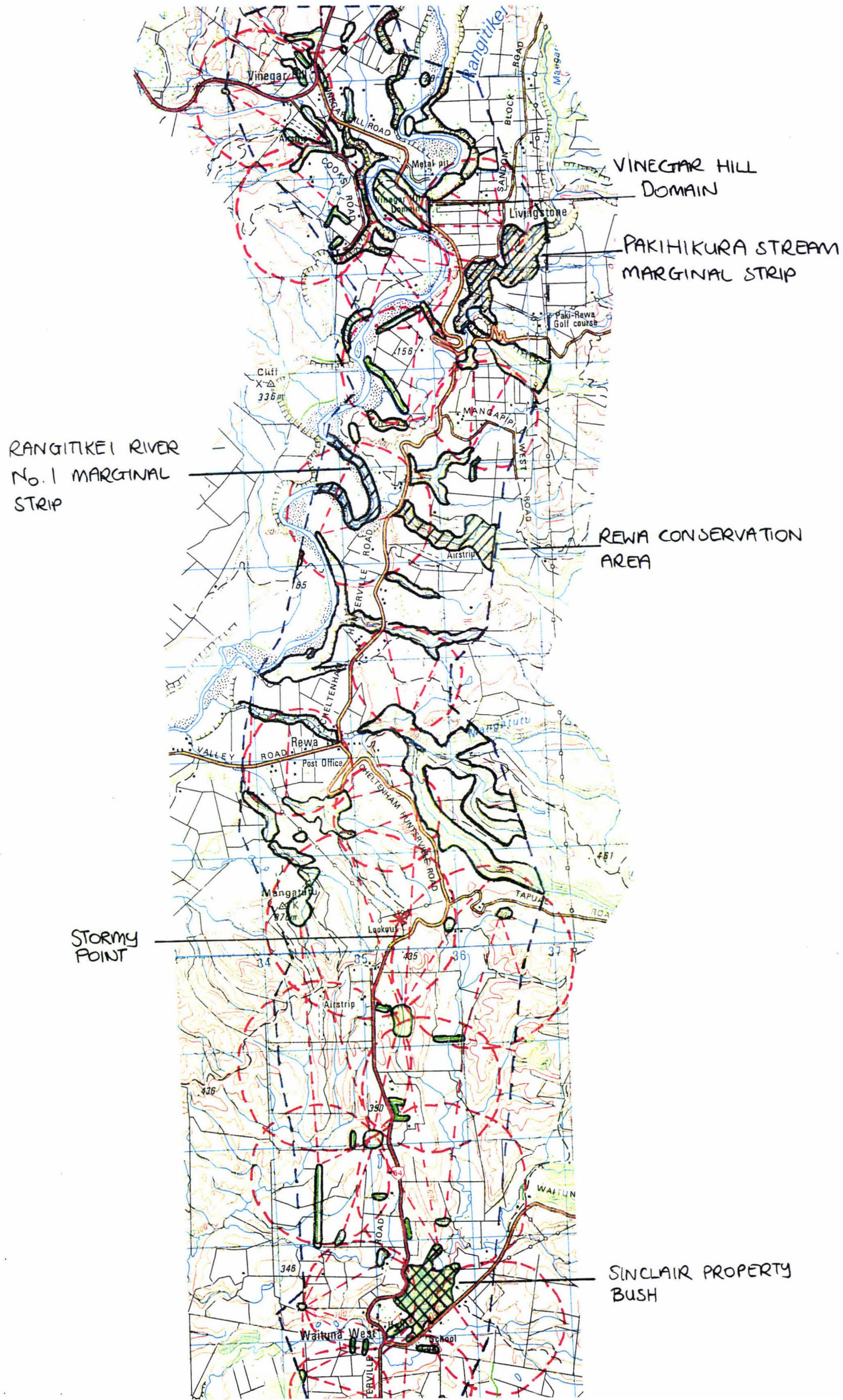


Figure A3.10C The Use of Vegetation To Reduce Speed



Note: The final overlays for each case study included in Chapter Five on pages:

APPENDIX 4: CASE STUDY ONE STATE HIGHWAY 54 MAP OVERLAYS



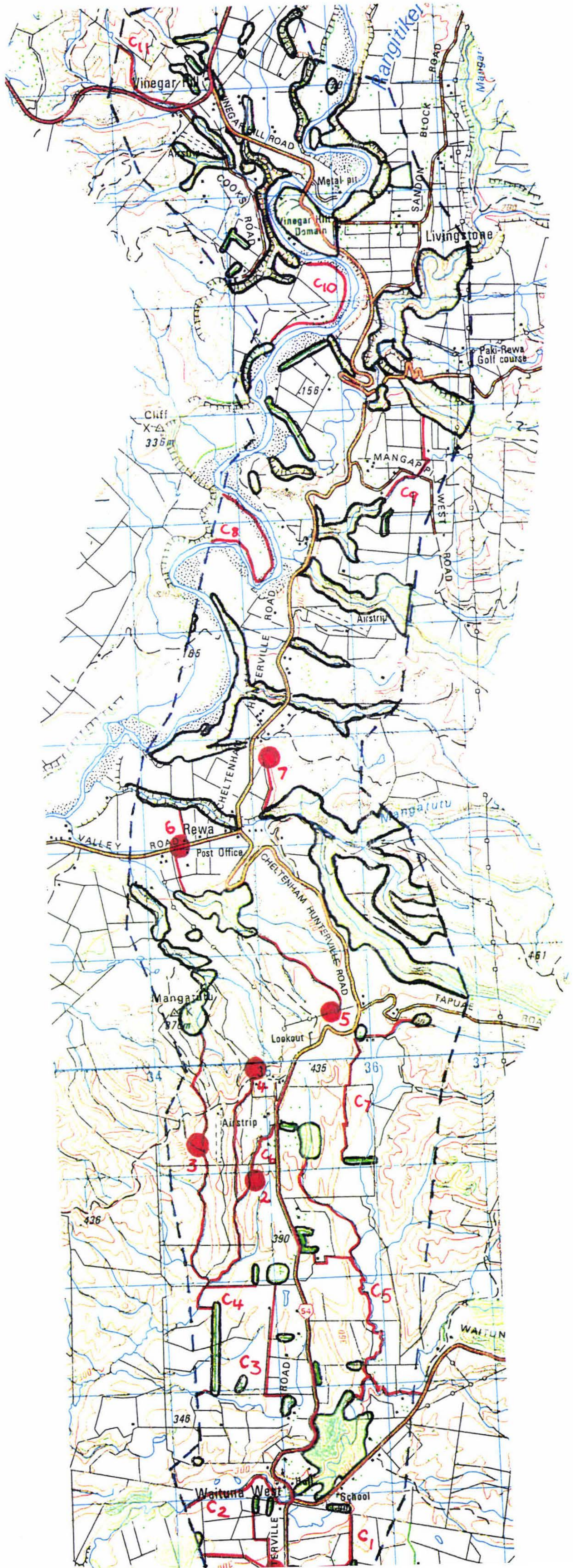
NORTH

Greenway To The Future? The Use of Greenways In Roading Management
Rochelle Viles

LEGEND:
Case study boundary
Existing Patches and Corridors
Responsible Agencies For Each:
Landowner
Department of Conservation
Territorial Authority
Identified in district plan only
Identified as RAP
Lookouts
Connectivity Circle Units
Possible New Connections

Note: Map Derived From Topographic Maps: NZMS 260 T22 Edition 1 1983 [1990] and T23 Edition 1 1982 [1996]. Standard legend applies for all base information.
Scale: 1:50 000

Map Number: 5.3A
State Highway 54 Overlay Number: One

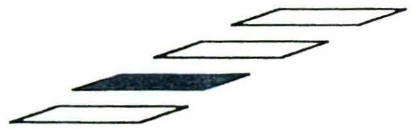


NORTH

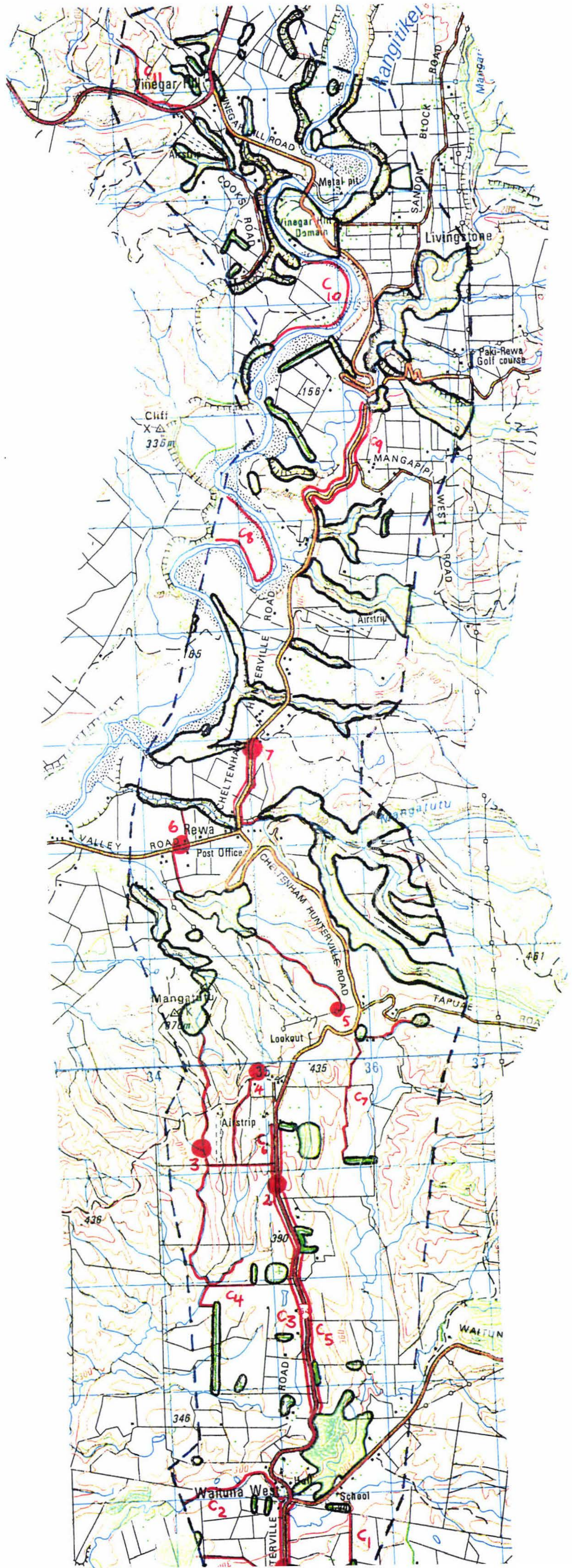
Greenway To The Future? The Use of Greenways In Roading Management
Rochelle Viles

LEGEND:
Existing Patches and Corridors
Proposed Patches
Proposed Corridors

Note: Map Derived From Topographic Maps: NZMS 260 T22 Edition 1 1983 [1990] and T23 Edition 1 1982 [1996]. Standard legend applies for all base information.
Scale: 1:50 000



Map Number: 5.3B
State Highway 54 Overlay Number: Two

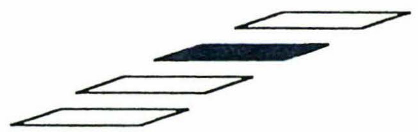


NORTH

Greenway To The Future? The Use of Greenways In Roading Management
Rochelle Viles

LEGEND:
Existing Patches and Corridors
Proposed Patches
Proposed Corridors

Note: Map Derived From Topographic Maps: NZMS 260 T22 Edition 1 1983 [1990] and T23 Edition 1 1982 [1996]. Standard legend applies for all base information.
Scale: 1:50 000



Map Number: 5.3C
State Highway 54 Overlay Number: Three

APPENDIX 4: CASE STUDY TWO POHANGINA VALLEY EAST ROAD MAP OVERLAYS

NORTH

Greenway To The Future? The Use of Greenways In Roading Management
Rochelle Viles

LEGEND:
Case study boundary
Existing Patches and Corridors
Responsible Agencies For Each:
Landowner
Department of Conservation
Territorial Authority
Identified in district plan only
Identified as RAP
Lookouts
Connectivity Circle Units
Possible New Connections

Note: Map Derived From Topographic Maps: NZMS 260 T23 Edition 1 1982 [1996]. Standard legend applies for all base information.
Scale: 1:50 000

Map Number: 5.4A
Pohangina Valley East Road Overlay
Number: One

NORTH

Greenway To The Future? The Use of Greenways In Roading Management
Rochelle Viles

LEGEND:

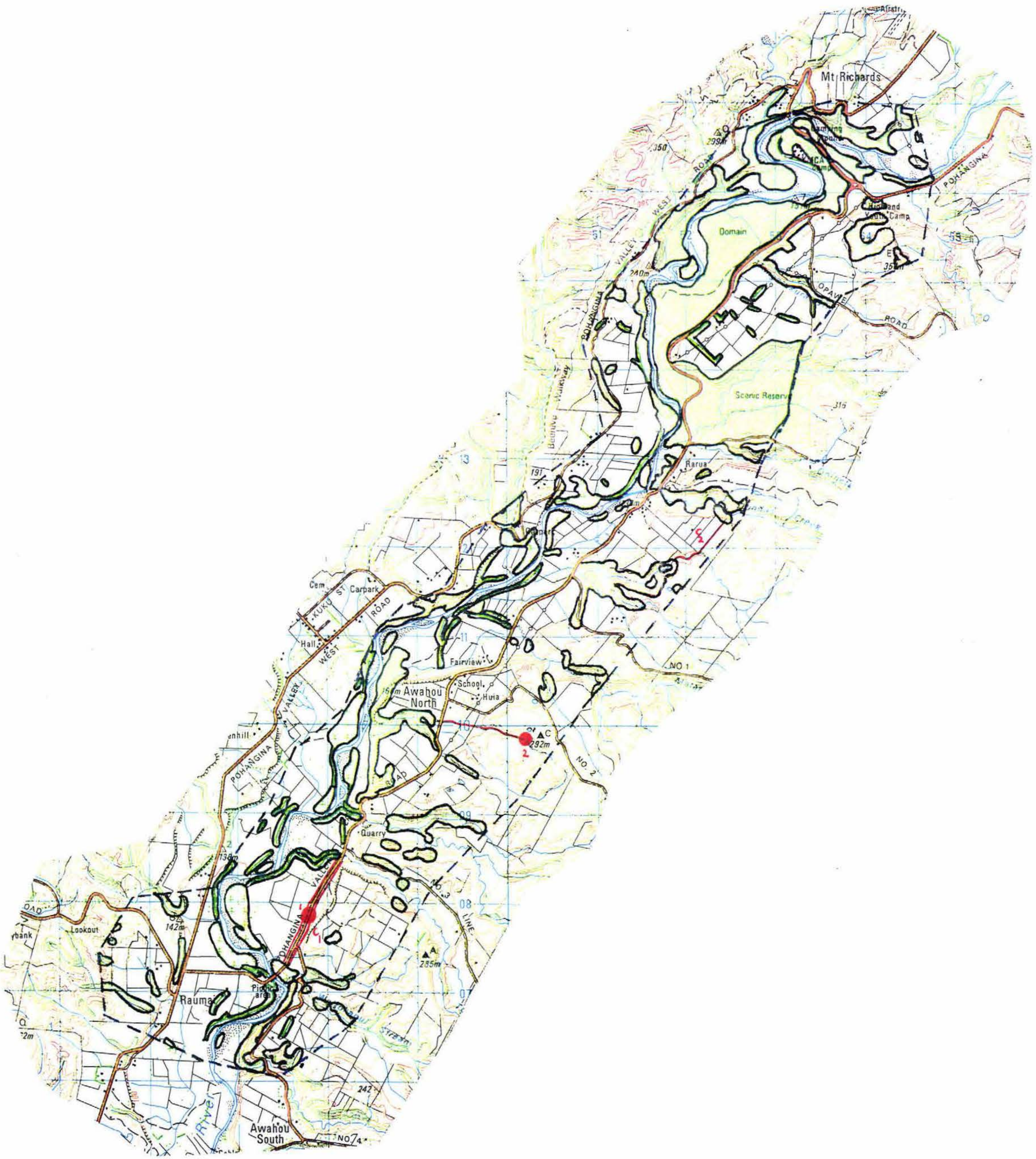
Existing Patches and Corridors

Proposed Patches

Proposed Corridors

Note: Map Derived From Topographic Map: NZMS 260 T23 Edition 1 1982 [1996]. Standard legend applies for all base information.
Scale: 1:50 000

Map Number: 5.4B
Pohangina Valley East Road Overlay
Number: Two

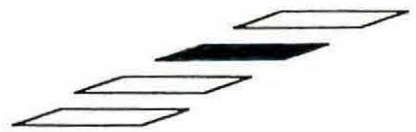


NORTH

Greenway To The Future? The Use of Greenways In Roading Management
Rochelle Viles

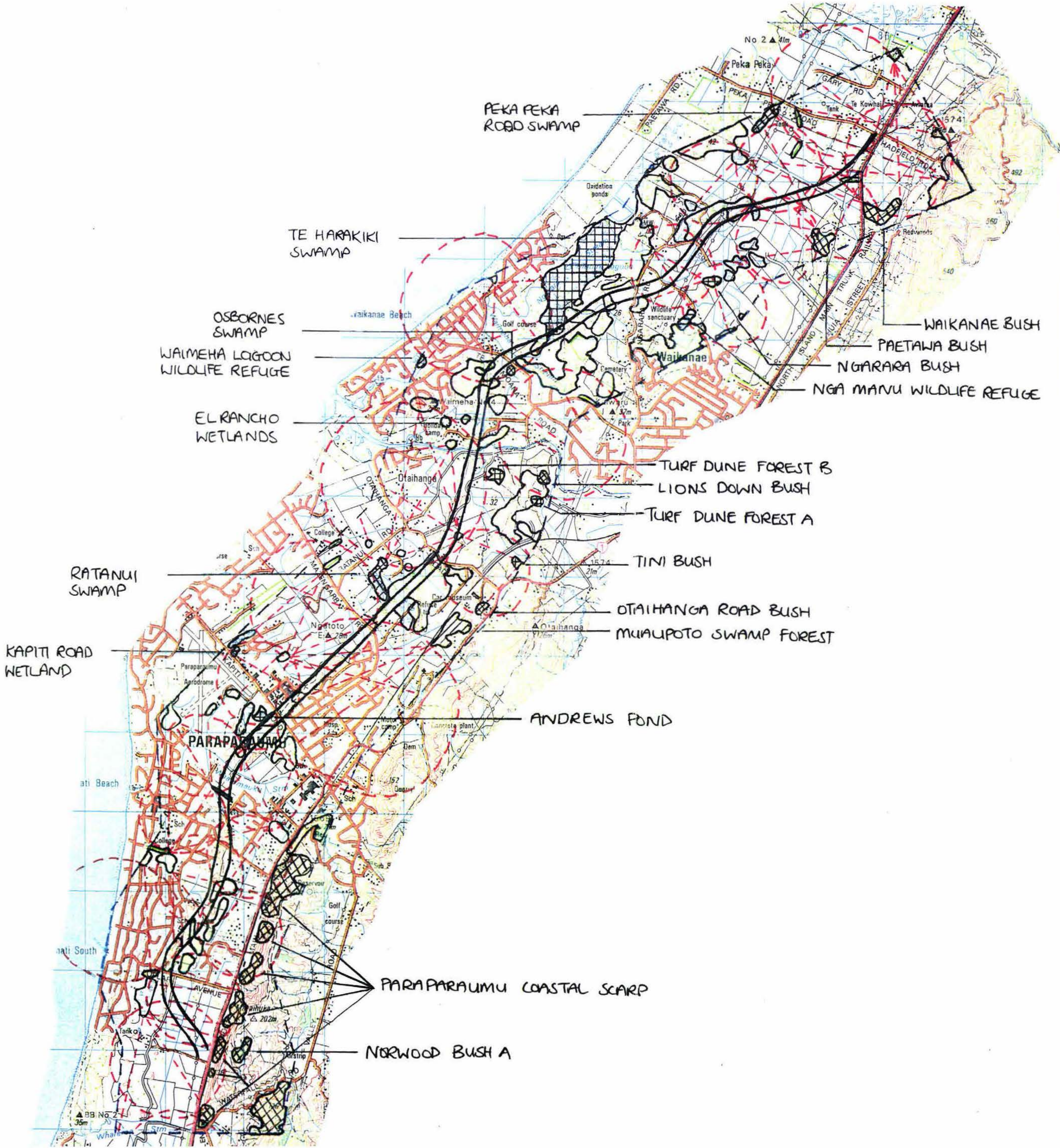
LEGEND:
Existing Patches and Corridors
Proposed Patches
Proposed Corridors

Note: Map Derived From Topographic Map: NZMS 260 T23 Edition 1 1982 [1996]. Standard legend applies for all base information.
Scale: 1:50 000



Map Number: 5.4C
Pohangina Valley East Road Overlay
Number: Three

APPENDIX 4: CASE STUDY THREE SANDHILLS BYPASS MAP OVERLAYS



NORTH

Greenway To The Future? The Use of Greenways In Roading Management
Rochelle Viles

LEGEND:

- Case study boundary
- Proposed Sandhills Bypass
- Existing Patches and Corridors
- Responsible Agencies For Each:
  - Landowner
  - Department of Conservation
  - Territorial Authority
  - Identified in district plan only
  - Identified as RAP
  - Private Trust
- Connectivity Circle Units
- Possible New Connections

Note: Map Derived From Topographic Map: NZMS 260 R26 & Pt. R25 Edition 2 1993. Standard legend applies for all base information.
Scale: 1:50 000

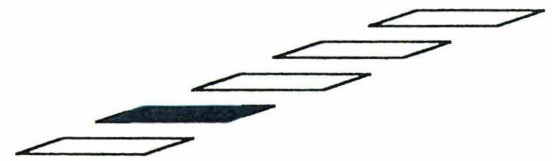
Map Number: 5.5A
Sandhills Bypass Overlay Number: One

NORTH

Greenway To The Future? The Use of Greenways In Roading Management
Rochelle Viles

LEGEND:
Proposed Sandhills Bypass
Components of "The Great Swamp" in 1840 as recorded by Carkeek in 1966 (Source: KCDC, 1993a:6)

Note: Map Derived From Topographic Map: NZMS 260 R26 & Pt. R25 Edition 2 1993. Standard legend applies for all base information.
Scale: 1:50 000



Map Number: 5.5B
Sandhills Bypass Overlay Number: Two

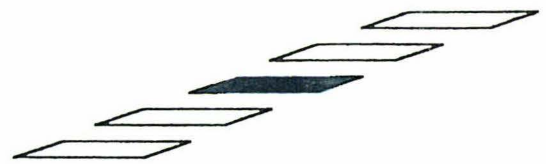
NORTH

Greenway To The Future? The Use of Greenways In Roading Management
Rochelle Viles

LEGEND:

- Proposed Sandhills Bypass
- Existing patches and corridors
- Proposed vegetation patches
- Proposed wetland patches
- Proposed vegetation corridors
- Proposed wetland corridors

Note: Map Derived From Topographic Map: NZMS 260 R26 & Pt. R25 Edition 2 1993. Standard legend applies for all base information.
Scale: 1:50 000



Map Number: 5.5C
Sandhills Bypass Overlay Number: Three

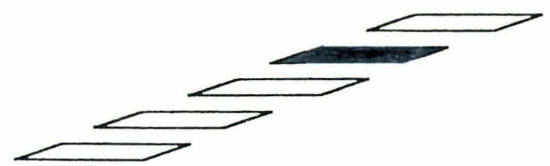
NORTH

Greenway To The Future? The Use of Greenways In Roading Management
Rochelle Viles

LEGEND:

Proposed Sandhills Bypass	
Existing patches and corridors	
Proposed vegetation patches	
Proposed wetland patches	
Proposed vegetation corridors	c_1
Proposed wetland corridors	c_1

Note: Map Derived From Topographic Map: NZMS 260 R26 & Pt. R25 Edition 2 1993. Standard legend applies for all base information.
Scale: 1:50 000



Map Number: 5.5D
Sandhills Bypass Overlay Number: Four

BIBLIOGRAPHY

CITED AND GENERAL SOURCES

Ahern, J. 1991 Planning for an extensive open space system: linking landscape structure and function. *Landscape and Urban Planning* 21, 131-145.

Ahern, J. 1995 Greenways as a planning strategy. *Landscape and Urban Planning* 33, 131-155.

Alexander, C., S. Ishikawa, M. Silverstein, M. Jacobson, I. Fiksdahl-King, S. Angel, 1977 *A Pattern Language*. Oxford University Press, New York.

Anderson, J., B.H. Durston, M. Poole, 1970 *Thesis and Assignment Writing*. John Wiley and Sons Australasia Pty. Ltd., Sydney.

Barber, M. 1991 Green belts - Outmoded Concepts or Challenge for the Future. *Planning Quarterly*, 102, 3-7.

Barrett, G.W. and P.J. Bohlen, 1991 Landscape Ecology. In: W.E. Hudson, (Editor) *Landscape Linkages and Biodiversity: Defenders of Wildlife*. Island Press, Washington D.C.

Baschak, L.A. and R.D. Brown, 1995 An ecological framework for the planning, design and management of urban river greenways. *Landscape and Urban Planning* 33, 211-225.

Beca Carter Holdings & Ferner Ltd and Traffic Design Group Ltd, 1995 *Kapiti Roading Study: Network Definition Study.* Beca Carter Holdings & Ferner Ltd, Wellington.

Beca Carter Holdings & Ferner Ltd and Traffic Design Group Ltd, 1996 *Kapiti Roading Study: Network Implementation Report*. Beca Carter Holdings & Ferner Ltd, Wellington.

Bennett, A.F. 1991 Roads, Roadsides and Wildlife Conservation: A Review. In: D.A. Saunders and R.J. Hobbs (Editors) *Nature Conservation 2: The Role of Corridors*. Surrey Beatty & Sons Pty Limited, Norton, Australia.

Binford, M.W. and M.J. Buchenau, 1993 Riparian Greenways and Water Resources. In: D.S. Smith and P.C. Hellmund (Editors), *Ecology of Greenways: Design and Function of Linear Conservation Areas*. University of Minnesota Press, Minneapolis.

Bischoff, A. 1995 Greenways as vehicles for expression. *Landscape and Urban Planning* 33, 317-325.

Bouma, G.D.1984 *The Research Process*. Oxford University Press, Melbourne.

Briggs, L. 1996 A Natural Environment Strategy for Christchurch. *Planning Quarterly*, March 120, 8-12.

Bueno, J.A., Vassilios, A.T., Alvarez, L. 1995 South Florida greenways: a conceptual framework for the ecological reconnectivity of the region. *Landscape and Urban Planning* 33, 247-266.

Buhrs, T. and Bartlett, R.V., 1993 *Environmental Policy in New Zealand: the Politics of Clean & Green*? Oxford University Press, Oxford.

Burel, F. and J. Baudry, 1995 Social, aesthetic and ecological aspects of hedgerows in rural landscapes as a framework for greenways. *Landscape and Urban Planning* 33, 327-340.

Burley, J.B. 1995 International greenways: a Red River Valley case study. *Landscape and Urban Planning* 33, 195-210.

Clout, M.N. and A.J. Saunders, 1995 Conservation and Ecological Restoration in New Zealand, In: *Pacific Conservation Biology*, 2(1), 91-98.

Cocklin, C. 1994 Managing and Protecting Biodiversity: A Private Land Perspective. In: *Biodiversity Conference*, Institute for International Research, Biological Resource Management, 4 & 5 August.

Collier, K.J., A.B. Cooper, R.J. Davies-Colley, J.C. Rutherford, C.M. Smith, and R.B. Williamson, 1995 *Managing Riparian Zones - A Contribution to Protecting New Zealand Rivers and Streams*. Volume 1: Concepts. pp.7-28.

Cooper, M.A. 1991 Too many users: the tragedy of the commons in rural roadsides. In: : D.A. Saunders and R.J. Hobbs (Editors) *Nature Conservation 2: The Role of Corridors*. Surrey Beatty & Sons Pty Limited, Norton, Australia.

Cross, H.C., P.D. Wetten, F.M. Keenan, 1991 Corridors for Wetland Conservation and Management? Room for Conjecture. In: D.A. Saunders and R.J. Hobbs (Editors) *Nature Conservation 2: The Role of Corridors*. Surrey Beatty & Sons Pty Limited, Norton, Australia.

Crowe, S. 1956 *Tomorrow's Landscape*. The Architectural Press, London.

Crowley, J.M. 1991 Roadside Protection: Newfoundland's Protected Road Zoning Programme. *Journal of the American Planning Association*, 57(1), 85-92.

Cutting, M. 1994 Local Government's Role in Biodiversity. In: *Biodiversity Conference*, Institute for International Research, Biological Resource Management, 4 & 5 August.

Daniels, R.E. 1988 The Role of Ecology in Planning: Some Misconceptions, *Landscape and Urban Planning*, 15, 291-300.

Dawson, R.L. and J.P. van der Breggen, 1991 Re-establishment and Maintenance of Indigenous Vegetation in South African Road Reserves. In: D.A. Saunders and R.J. Hobbs (Editors) *Nature Conservation 2: The Role of Corridors*. Surrey Beatty & Sons Pty Limited, Norton, Australia.

Department of Conservation [DoC], 1992: *Foxton Ecological Region: Survey Report for the Protected Natural Areas Programme*. Department of Conservation, Wanganui.

Department of Conservation [DoC], 1993a Riparian and Coastal Values and Consideration for Protection. In: New Zealand Institute of Surveyors, Ministry for the Environment, Department of Conservation and Simpson Grierson and Butler White, *Seminar Papers on Subdivisions and Esplanades Under the Amended Resource Management Act*. Wellington.

Department of Conservation [DoC], 1993b *Wanganui Conservancy Conservation Management Strategy: Issues and Options Public Discussion Document.* Department of Conservation, Wanganui.

Department of Conservation [DoC], 1994a *Hawke's Bay Conservancy Conservation Management Strategy: Volumes One and Two.* Department of Conservation, Napier.

Department of Conservation [DoC], 1994b *New Zealand's Biodiversity: An Overview.* Department of Conservation, Wellington.

Department of Conservation [DoC], 1995a *Manawatu Plains Ecological Region: Survey Report for the Protected Natural Areas Programme.* Department of Conservation, Wanganui.

Department of Conservation [DoC], 1995b *Rangitikei Ecological Region: Survey Report for the Protected Natural Areas Programme.* Department of Conservation, Wanganui.

Department of Conservation [DoC], 1996 *Wellington Conservancy Conservation Management Strategy: Volumes One and Two.* Department of Conservation, Wellington.

Department of Conservation [DoC], 1997 *Wanganui Conservancy Conservation Management Strategy: Volumes One and Two.* Department of Conservation, Wanganui.

Dixon, J.E. 1993 The Integration of EIA and Planning in New Zealand: Changing Process and Practice. *Journal of Environmental Planning and Management,* 36(2), 239-251.

Dramstad, W.E., J.E. Olson, and R.T.T. Forman, 1996 *Landscape Ecology Principles in Landscape Architecture and Land-Use Planning.* Island Press, Washington, D.C.

Edwards, V.M. and Sharp, B.M.H. 1990 Institutional Arrangements for Conservation on Private Land in New Zealand. *Journal of Environmental Management* 31, 313-326.

Fabos, J.G., 1995 Introduction and overview: the greenway movement, uses and potentials of greenways. *Landscape and Urban Planning*, 33, 1-13.

Fahrig, L. and G. Merriam, 1994 Conservation of Fragmented Populations. *Conservation Biology*, 8(1), 50-59.

Fedorowick, J.M., 1993 A landscape restoration framework for wildlife and agriculture in the rural landscape. *Landscape and Urban Planning*, 27, 7-17.

Fleury, A.M. and R.D. Brown, 1997 A framework for the design of wildlife conservation corridors With specific application to southwestern Ontario. Landscape *and Urban Planning* 37, 163-186.

Forman, R.T.T. 1982 Interaction Among Landscape Elements: A Core of Landscape Ecology. In: S.P. Tjallingii and A.A. de Veer, *Perspectives in Landscape Ecology: Proceedings of the International Congress organised by the Netherlands Society for Landscape Ecology*, Centre for Agricultural Publishing and Documentation, Wageningen.

Forman, R.T.T. and Godron, M. 1986 *Landscape Ecology*. John Wiley & Sons, New York.

Froude, V. 1995 Significant Natural Features Gain Protection. *Planning Quarterly* 119, 20-23.

Froude, V. 1996 *Protecting biodiversity values on private land, and for marine and freshwater ecosystems*. Prepared for Resource Management: Issues, Visions, Practice Symposium: 5 - 8 July 1996, Lincoln University.

Fry, J., F.R. Steiner and D.M. Green, 1994 Riparian evaluation and site assessment in Arizona. *Landscape and Urban Planning*, 28, 179-199.

Garland, E.J. 1995 Green Belts - frames or fragments? *Scottish Geographical Magazine*, 111(2), 66-67.

Gilliam, J.W., L.A. Schipper, P.N. Beets, M. McConchie 1992 Riparian Buffers in New Zealand Forestry. *N.Z. Forestry* 21-25.

Gobster, P.H. 1995 Perception and use of a metropolitan greenway system for recreation. *Landscape and Urban Planning* 33, 401-413.

Gordon, R. 1996 *Report of the Restoration Forum held at Mount Albert Research Centre*. Landcare Research, Lincoln.

Greening Australia Ltd, 1995 *Local Greening Plans: A Guide for Vegetation and Biodiversity Management*, Greening Australia, Canberra.

Groome, D., 1990 "Green Corridors": a discussion of a planning concept. *Landscape and Urban Planning* 19, 383-387.

Grove, N. 1990 Greenways Paths to the Future. *National Geographic*, 177(6), 77-98.

Hackett, B. 1971 *Landscape Planning: An Introduction to Theory and Practice*. Oriel Press, Newcastle upon Tyne.

Halcrow Fox and Associates, 1993 *Land Transport Pricing for New Zealand*. Transit New Zealand Research Report No. 18.

Halloy, S.R.P. 1995 Status of New Zealand biodiversity research and resources: how much do we know? *Journal of The Royal Society of New Zealand*, 25(1) 55-80.

Harris L.D. and J. Scheck, 1991 From Implications to Applications: the Dispersal Corridor Principle Applied to the Conservation of Biological Diversity. In: D.A. Saunders and R.J. Hobbs (Editors) *Nature Conservation 2: The Role of Corridors*. Surrey Beatty & Sons Pty Limited, Norton, Australia.

Hay, K.G. 1991 Greenways and Biodiversity. In: W.E. Hudson, (Editor) *Landscape Linkages and Biodiversity: Defenders of Wildlife*. Island Press, Washington D.C.

Haynes, R. (ed) 1982 *Environmental Science Methods*. Chapman Hall Ltd, London.

Hayward, A.L. and Sparkes, J.J. 1982 *The Concise English Dictionary*. Omega Books, Hertfordshire.

Henderson, E. and de Lambert R. 1992 *Resource Management Ideas No. 4: Landscape Values and Resource Management.* Ministry for the Environment, Wellington.

Heywood, V.H. and Watson, R.T. 1996 *Global Biodiversity Assessment.* Cambridge University Press.

Hobbs, R.J., D.A. Saunders, G.W. Arnold, 1993 Integrated Landscape Ecology: A Western Australian Perspective. *Biological Conservation*, 64, 231-238.

Hoover, A.P. and Shannon, M.A. 1995 Building greenway policies within a participatory democracy framework. *Landscape and Urban Planning* 33, 433-459.

Hough, M. 1989 *City Form and Natural Process: Towards a New Urban Vernacular.* Routledge, London.

Hough, M. 1990 *Out of Place: Restoring Identity to the Regional Landscape.* Yale University Press, New Haven & London.

Hudson, E. 1991 (Editor) *Landscape Linkages and Biodiversity: Defenders of Wildlife.* Island Press, Washington D.C.

Jongman, R.H.G. 1995 Nature conservation planning in Europe: developing ecological networks. *Landscape and Urban Planning* 32, 169-183.

Kapiti Coast District Council [KCDC], 1993a *Kapiti Coast Proposed District Plan Discussion Paper No. 3: Rural Environment.* Kapiti Coast District Council, Paraparaumu.

Kapiti Coast District Council [KCDC], 1993b *Kapiti Coast Proposed District Plan Discussion Paper No. 4: Esplanade Reserves.* Kapiti Coast District Council, Paraparaumu.

Kapiti Coast District Council [KCDC], 1993c *Kapiti Coast Proposed District Plan Discussion Paper No. 2: Residential Environment.* Kapiti Coast District Council, Paraparaumu.

Kapiti Coast District Council [KCDC], 1995 *Proposed Kapiti Coast District Plan.* Kapiti Coast District Council, Paraparaumu.

Kent, R.L. and C.L. Ellliot, 1995 Scenic Routes Linking and Protecting Natural and Cultural Landscape Features: A Greenway Skeleton. *Landscape and Urban Planning*: 33, 341-355.

Kuiken, M. 1988 Consideration of Environmental and Landscape Factors in Highway Planning in Valued Landscapes: an Australian Survey. *Journal of Environmental Management:* 6, 191-201.

Kulinskis, V. 1992 *Roadside Management Guidelines Book 1: Main Road 55, Environmental Guidelines for Road Construction & Maintenance Workers.* Roads and Traffic Authority and Greening Australia Central West, Molong.

Land & Water Resources Research & Development Corporation [LWRRDC] 1996a *Riparian Management 1: Managing Riparian Land.* LWRRDC, Canberra.

Land & Water Resources Research & Development Corporation [LWRRDC] 1996 *Riparian Management 2: Streambank Stability.* LWRRDC, Canberra.

Land & Water Resources Research & Development Corporation [LWRRDC] 1996 *Riparian Management 3: Water Quality.* LWRRDC, Canberra.

Land & Water Resources Research & Development Corporation [LWRRDC] 1996 *Riparian Management 4: River Ecosystems.* LWRRDC, Canberra.

Land & Water Resources Research & Development Corporation [LWRRDC] 1996b *Riparian Management 5: Land-based Ecosystems.* LWRRDC, Canberra.

Land & Water Resources Research & Development Corporation [LWRRDC] 1996c *Riparian Management 6: Managing Stock.* LWRRDC, Canberra.

Laws, G.R. 1987 *Tree Planting and Maintenance: Beautiful New Zealand Scheme.* Environmental Design Section, Town and Country Planning Directorate for the Advisory Committee of the Beautiful New Zealand Scheme, Wellington.

Leedy, P.D. 1997 *Practical Research: Planning and Design*. Fourth edition. Macmillan Publishing Company, New York.

Lewis, P.H. 1964 Quality Corridors in Wisconsin. *Landscape Architecture*, 54 (2) 100-107.

Lineham, J., M. Gross, and J. Finn, 1995 Greenway planning: developing a landscape ecological network approach. *Landscape and Urban Planning*: 33, 179-193.

Little, C.E. 1990 *Greenways for America*. The Johns Hopkins University Press, Baltimore.

Little, C.E. 1991 Prospect. *Landscape Architecture*, 81(1), 12.

Loney, B. and R.J. Hobbs 1991 Management of Vegetation Corridors: Maintenance, Rehabilitation and Establishment. In: D.A. Saunders and R.J. Hobbs (Editors) *Nature Conservation 2: The Role of Corridors*. Surrey Beatty & Sons Pty Limited, Norton, Australia.

Longley, P., M. Batty, J. Shepherd, G. Sadler, 1991 Do Green Belts Change the Shape of Urban Areas? A Preliminary Analysis of the Settlement Geography of South East England. *Regional Studies*, 26.5, 437-452.

Luymes, D.T. and K. Tamminga. 1995 Integrating public safety and use into planning urban greenways. *Landscape and Urban Planning*: 33, 391-400.

Lynch, K. 1982 *A Theory of Good City Form*. The Massachusetts Institute of Technology Press, Massachusetts.

Lynch, J.F. and D.A. Saunders, 1991 Responses of Bird Species to Habitat Fragmentation in the Wheatbelt of Western Australia: Interiors, Edges and Corridors. In: D.A. Saunders and R.J. Hobbs (Editors) *Nature Conservation 2: The Role of Corridors*. Surrey Beatty & Sons Pty Limited, Norton, Australia.

Lynch, J.F., W.F. Carmen, D.A. Saunders, P. Cale, 1996 Use of Vegetated Road Verges and Habitat Patches by Four Bird Species in the Central Wheatbelt of Western Australia. In: D.A. Saunders, J.L. Craig and E.M. Mattiske (Editors)

Nature Conservation 4: The Role of Networks. Surrey Beatty & Sons Pty Limited, Norton.

McGuckin, C.P. and R.D. Brown, 1995 A landscape ecological model for wildlife enhancement of stormwater management practices in urban greenways. *Landscape and Urban Planning*, 33, 227-246.

McHarg, I.L. 1971 *Design With Nature*. Doubleday/Natural History Press, New York.

McNeely, J.A., K.R. Miller, W.V. Reid, R.A. Mittermeier, T.B. Werner, 1990 *Conserving the World's Biological Diversity*. IUCN, WRI, Conservation International, WWF, World Bank, Gland, Switzerland.

Manawatu District Council [MDC], 1997 *Draft Manawatu District Plan*. Manawatu District Council, Feilding.

Manawatu Wanganui Regional Council [MWRC], 1993 *Regional Land Transport Strategy*. Manawatu Wanganui Regional Council, Palmerston North.

Manawatu Wanganui Regional Council [MWRC], 1995a *Proposed Manawatu Catchment Water Quality Regional Plan*. Manawatu Wanganui Regional Council, Palmerston North.

Manawatu Wanganui Regional Council [MWRC], 1995b *Proposed Regional Policy Statement for Manawatu Wanganui*. Manawatu Wanganui Regional Council, Palmerston North.

Marshall, D. 1994 Why is Biological Diversity so Economically and Socially Important? In: *Institute for International Research, Biological Resource Management* 4 & 5 August.

Mason, B. 1994 Private Management of 'the Public Interest'? *PANZ Monograph Series* Number 7.

Memon, P.A. 1993 *Keeping New Zealand Green: Recent Environmental Reforms*. University of Otago Press, Dunedin.

Memon, P.A. and Gleeson, B.J. 1995 Towards a new planning paradigm? Reflections on New Zealand's Resource Management Act. *Environment and Planning B: Planning and Design*, 22, 109-124.

Merriam, G. (1991) Corridors and Connectivity: Animal Populations in Heterogeneous Environments. In: D.A. Saunders and R.J. Hobbs (Editors) *Nature Conservation 2: The Role of Corridors*. Surrey Beatty & Sons Pty Limited, Norton, Australia.

Milne, C.D.A. 1996 *Handbook of Environmental Law*. Royal Forest and Bird Society of New Zealand Inc., Wellington.

Ministry for the Environment, 1991 *Guide to the Resource Management Act 1991*. Ministry for the Environment, Wellington.

Ministry for the Environment, 1992 *Guideline for District Plans*. Ministry for the Environment, Wellington.

Ministry for the Environment, 1993 *Information Kit: Resource Management Amendment Act 1993*, Ministry for the Environment, Wellington.

Ministry of Transport 1996 Land Transport Pricing Study. *Environmental Externalities: Discussion Paper*. Ministry of Transport, Wellington.

Ministry of Transport, 1997 *Road Reform: The Way Forward. Roading Advisory Group Final Report*, Ministry of Transport, Wellington.

Ministry of Works and Development, 1984 *Design Guidelines Beautiful New Zealand*. Government Printer, Wellington.

Mosley, B. March 1996 Riparian Management - A Rural Perspective. *Planning Quarterly* 120: 18-19.

Naveh, Z. & Lieberman, A. 1994 *Landscape Ecology: Theory and Application*. Springer-Verlag, New York.

New Zealand Institute of Surveyors, Ministry for the Environment, Department of Conservation and Simpson Grierson and Butler White, 1993 *Seminar Papers On: Subdivisions and Esplanades Under the Amended Resource Management Act.*

Norton, D.A. 1991 Scientific Basis for the Conservation Management of New Zealand Plant Communities. In: I.F. Spellerberg, F.B. Goldsmith and M.G. Morris (eds), *The Scientific Management of Temperate Communities for Conservation.* Blackwell Scientific Publications, Oxford.

Noss, R.F. 1983 A Regional Landscape Approach to Maintain Diversity. *BioScience*, 33(11), 700-706.

Noss, R.F. 1991 Landscape Connectivity: Different Functions at Different Scales. In: Hudson, E. (Editor) *Landscape Linkages and Biodiversity: Defenders of Wildlife.* Island Press, Washington D.C.

Noss, R.F. 1993 Wildlife Corridors. In: Smith, D.S. & Hellmund, P.C. (eds) *Ecology of Greenways: Design and Function of Linear Conservation Areas.* University of Minnesota Press, Minneapolis.

O'Flaherty, C.A. 1974 *Highways Volume 1: Highways and Traffic.* (Second Edition) Edward Arnold, London.

Ogden, J. 1995 The Long-Term Conservation of Forest Diversity in New Zealand, In: *Pacific Conservation Biology*, 2(1), 77-90.

Ogle, C.C. 1987 The Incidence and Conservation of Animal and Plant Species in Remnants of Native Vegetation within New Zealand. In: D.A. Saunders, G.W. Arnold, A.A. Burbidge and A.J.M. Hopkins (eds) *Nature Conservation: The Role of Remnants of Native Vegetation.* Surrey Beatty & Sons Pty Limited, Chipping Norton.

Opus International Consultants, 1997a Kapiti *Urban Roading Project Options and Issues Report: Working Paper No.7 Assessment of Environmental Effects of Recommended Alignment.* Opus International Consultants, Wellington.

Opus International Consultants, 1997b *Kapiti Urban Roading Project Options and Issues Report.* Opus International Consultants, Wellington.

Palka, E.J. 1995 Coming to Grips with the Concept of Landscape. *Landscape Journal* 14(1) Spring, 63-73.

Pannetta F.D. and A.J.M. Hopkins 1991 Weeds in Corridors: Invasion and Management. In: D.A. Saunders and R.J. Hobbs (Editors) *Nature Conservation 2: The Role of Corridors*. Surrey Beatty & Sons Pty Limited, Norton, Australia.

Rangitikei District Council [RDC], 1995a *Proposed Rangitikei District Plan*, Rangitikei District Council, Marton.

Rangitikei District Council [RDC], 1995b *Rangitikei District Reserves Management Strategy*, Works Consultancy Services, Wellington.

Rosenow, J.E. and G.L. Pulsipher 1979 *Tourism: the Good, the Bad, and the Ugly*. Media Productions & Marketing, Nebraska.

Rosier, J. 1993 *Management of Pauatahanui Inlet Discussion Document*, Wellington Regional Council, Wellington.

Royal Forest and Bird Protection Society of New Zealand, 1995 *Stopping the Bulldozers Before They Start: The Forest and Bird Guide to Resource Management Plans*. Royal Forest and Bird Protection Society of New Zealand, Wellington.

Ryan, J.C. 1992 *Life Support: Conserving Biological Diversity*. Worldwatch Institute, Washington D.C.

Ryder, B.A. 1995 Greenway planning and growth management: partners in conservation? *Landscape and Urban Planning* 33, 417-432.

Sage, E. March 1992 Creative Schemes Protect Forest. *Planning Quarterly* 105, 6-8.

Saunders D.A. and R.J. Hobbs 1991 (Editors) *Nature Conservation 2: The Role of Corridors*. Surrey Beatty & Sons Pty Limited, Norton, Australia.

Schrader, C.C. 1995 Rural greenway planning: the role of streamland perception in landowner acceptance of land management strategies. *Landscape and Urban Planning* 33, 375-390.

Searns, R.M. 1995 The evolution of greenways as an adaptive urban landscape form. *Landscape and Urban Planning* 33, 65-80.

Shannon, S., Smardon, R., Knudson, M. 1995 Using Visual Assessment as a foundation for greenway planning in the St. Lawrence River Valley. *Landscape and Urban Planning* 33, 357-371.

Smith, D.S., 1993 An Overview of Greenways: Their History, Ecological Context, and Specific Functions. In: D.S. Smith and P.C. Hellmund (eds), *Ecology of Greenways: Design and Function of Linear Conservation Areas*. University of Minnesota Press, Minneapolis.

Soule, M.E. 1991 Land Use Planning and Wildlife Maintenance: Guidelines for Conserving Wildlife in an Urban Landscape. *APA Journal*, Summer, 313-323.

Spellerberg, I.F. 1992 *Evaluation and Assessment for Conservation.* Chapman and Hall.

Stewart, A.J.A. and M.J. Hutchings 1996 Conservation of Populations. In: I.F. Spellerberg, *Conservation Biology*, Longman, Essex.

Swaffield, S.R. and K.F. O'Connor, 1986 *Perceiving, Conceiving, Protecting and Using New Zealand Landscape Systems*, Information Paper No. 6. Paper Presented at the International Conference on Landscape of the Southern Hemisphere, Adelaide, South Australia.

Taranaki Regional Council, 1992 *Protection of Outstanding Natural Features and Landscapes*. Taranaki Regional Council, Stratford.

Taylor, J., C. Paine, J. FitzGibbon, 1995 From greenbelt to greenways: four Canadian case studies. *Landscape and Urban Planning* 33, 47-64.

Thomas, C.D. 1991 *Ecological Corridors: An Assessment.* Department of Conservation, Wellington.

Thorne, J.F. 1993 Landscape Ecology: A Foundation for Greenway Design. In: D.S. Smith and P.C. Hellmund (eds), *Ecology of Greenways: Design and Function of Linear Conservation Areas*. University of Minnesota Press, Minneapolis.

Transit New Zealand, 1994 *Planning for a Safe and Efficient State Highway Network Under the Resource Management Act 1991: A Guideline By Transit New Zealand.* Transit New Zealand, Wellington.

Transit New Zealand, no date *Transit New Zealand and the Environment. Transit* New Zealand, Wellington.

Turner, T. 1991 Pattern Analysis. *Landscape Design*, 204, 39-41.

Turner, T. 1995 Greenways, blueways, skyways and other ways to a better London. *Landscape and Urban Planning* 33, 269-282.

Turner, T. 1996a *City as Landscape*. E & FN Spon, London.

Turner, T. 1996b From No Way to Greenway. *Landscape Design* 254, 17-20.

Tzolova, G.V. 1995 An experiment in greenway analysis and assessment: the Danube River. *Landscape and Urban Planning* 33, 283-294.

Upton, S. 1996 *Sustainability and the place of amenity values and landscape*. Proceedings from the EAROPH World Planning Congress.

Upton, S. 1997 *The Efficient Use and Development of Natural and Physical Resources*. [Presented to the 5th Annual Resource Management Law Association Conference, 1997].

Walmsley, A. 1995 Greenways and the making of urban form. *Landscape and Urban Planning* 33, *81-127*.

Wellington Regional Council [WRC], 1993 *Queen Elizabeth Park Management Plan Part I: Aims, Objectives and Policies*. Welligton Regional Council, Wellington.

Wellington Regional Council [WRC], 1993 *Queen Elizabeth Park Management Plan Part Two: Resource Statement*. Welligton Regional Council, Wellington.

Wellington Regional Council [WRC], 1995 *Regional Policy Statement for the Wellington Region,* Wellington Regional Council, Wellington.

Wellington Regional Council [WRC], 1996 *Draft Regional Landscape Plan.* Wellington Regional Council, Wellington.

Wellington Regional Council [WRC], 1997 *Proposed Regional Freshwater Plan.* Wellington Regional Council, Wellington.

Whyte, W.H. 1968 *The Last Landscape.* Doubleday & Company, Inc. Garden City, New York.

Yahner, T.G., N. Korostoff, T.P. Johnson, A.M. Battaglia, D.R. Jones, 1995 Cultural landscapes and landscape ecology in contemporary greenway planning, design and management: a case study. *Landscape and Urban Planning*, 33, 295-316.

Yin, R.K. 1989 *Case Study Research: Design and Methods.* Sage Publications, California.

Zube, E. H. 1995 Greenways and the US National Park System. *Landscape and Urban Planning* 33, 17-25.

MAPS

Kapiti Coast District Council [KCDC], 1995 *Proposed Kapiti Coast District Planning Maps*, KCDC, Paraparaumu.

Kimbolton 1982 New Zealand Cadastral Map, 1:50 000, NZMS 261 Edition 2 Sheet T23 Department of Land and Survey Information, Wellington.

Kimbolton 1982 [Reprinted 1996] New Zealand Topographic Map, 1:50 000, NZMS 260 Edition 1 Sheet T23 Land Information New Zealand, Wellington.

Managerial: The North 1988 [Reprinted 1995] Local Authority Boundaries Infomap, 1: 50 000, Edition 3 Department of Land and Survey Information, Wellington.

Manawatu District Council [MDC] 1997 *Manawatu District Floodmaps: Draft District Plan*, MDC, Feilding.

Mangaweka 1983 [Reprinted 1990] New Zealand Topographic Map, 1:50 000, NZMS 260 Edition 1 Sheet T22 Department of Land and Survey Information, Wellington.

Mangaweka 1984 New Zealand Cadastral Map, 1:50 000, NZMS 261 Edition 2 Sheet T23 Department of Land and Survey Information, Wellington.

Paraparaumu 1993 New Zealand Topomap, 1:50 000, NZMS 260 Edition 2 R26 & Pt. R25 Department of Land and Survey Information, Wellington.

Rangitikei District Council [RDC], 1995 *Proposed Rangitikei District Planning Maps*, RDC, Marton.

Wellington, Palmerston North and Wanganui, 1997 Itinerary North Island N5, 1:600 000 Edition 2, New Zealand Automobile Association Inc., Auckland.

Wellington and Wairarapa 1991 District Map, 1:350 000 Edition 1, The Automobile Association, Auckland.

STATUTES

Conservation Act 1987
Local Government Act 1974 [1990]
Resource Management Act 1991 [1995]
Transit New Zealand Act 1989