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# Conserving and Restoring Biodiversity in New Zealand Urban and Rural Environments

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A continuing education course and resource manual



**Landcare Research**  
**Manaaki Whenua**



**UNIVERSITY OF  
FLORIDA**





## Preface and acknowledgements

'Conserving and restoring biodiversity in New Zealand urban and rural environments' is a course intended to provide information to professionals and stakeholder groups on how to design, construct, and manage human-modified environments for biodiversity. Application of this knowledge will protect New Zealand's natural habitat and species diversity while meeting the country's housing needs in a sustainable and healthy way.

Many people have contributed to these materials, which also include information from a wide variety of books, periodicals, and online resources. This manual was adapted from an original course, designed by Hal Knowles and Mark Hostetler and developed at the University of Florida in 2005, called Preserving Wildlife Habitat in Residential Developments. The course is targeted at growing communities in Florida and is currently being taught to various stakeholders in that US state. As part of Mark Hostetler's sabbatical in New Zealand (2007–08) on a 2008 Fulbright US Senior Scholarship, with Landcare Research (a Crown Research Institute), he adapted this original Florida course for New Zealand conditions. The various contributors to this course each played a special role in creating this product; a sincere thanks and appreciation goes out to each one. In particular, my esteemed colleague Colin Meurk contributed significantly to this course and special thanks is extended for his wisdom, guidance, and friendship during this project, without which it would have never have got off the ground. Colin is a truly remarkable fellow and I genuinely admire his expertise, appetite, and passion for biological conservation in New Zealand. In addition, thanks goes to Landcare Research and its Low Impact Urban Design and Development (LIUDD) Programme for providing support and a stimulating atmosphere in which to forge new ideas and promote international collaborations. Special thanks to Michael Krausse for supporting this endeavour under the LIUDD Programme. Many conversations with Landcare Research colleagues and people associated with Lincoln Envirotown Trust (e.g., Sue Jarvis) led to ideas, links to documents, and content adjustment (from the US version) to reflect New Zealand conditions. Special thanks to Rhys Taylor, Kathryn Scott, Viv Heslop, Lynley Hayes, Eric Spurr, John Innes, Garth Harmsworth, Meryl Klein, and many others for their comments which ultimately helped shape the content of this course. **The manual was updated in 2025.**

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## Who should take this course

This course was designed for people whose jobs involve growth management and development, such as planners, policymakers, developers and other built environment professionals (landscape architects, architects, contractors, engineers, surveyors, etc.). The course is also applicable to rural landowners interested in conserving or restoring biodiversity on their land. Finally, the course is relevant for those of the general public with an interest in designing, managing, and sustaining biodiversity both within their region and local community (i.e. how a community grows) and on their own property (i.e. individual lot improvements) – this applies to subdivisions, small commercial properties, and larger rural lots.

## Goals for this course and how it should be taught

Many residential developments and rural properties are situated near or in habitats that sustain native plant and animal communities. Conserving or restoring the unique natural features inherent on every parcel of land (and associated aquatic environments) benefits the local environment, property owners, and the country's heritage. Much of this continuing education course (and a complementary urban greening manual produced by Landcare Research) is devoted to defining, recognising, restoring, and managing reconstructed communities within the urban and rural matrix. The places we live are dominated by buildings and/or agriculture, but they still offer opportunities to improve biodiversity and to minimise our consumption of natural resources. This course focuses on residential, small commercial and rural design and management at the subdivision or large-lot scale. While the emphasis is on new development, both within the urban core, periurban fringe, and rural fringe, the information presented here can be used to 'retrofit' existing urban communities as well as to conserve or restore rural properties that are not designated for subdivision.

Each community may be at different stages of awareness (in terms of biodiversity conservation) so this continuing education (CE) course must be adjusted accordingly. For example, one city may have a fairly robust biodiversity strategy that needs just a little tweaking; there, the CE course should concentrate on providing local practitioners with the knowledge and tools to implement the strategy. In other regions, it might be that the biodiversity strategy is in its infancy or under revision and the CE course could be a catalyst for communication among planners/policymakers, built environment professionals, and the public. After this course and subsequent workshops, the end product would be a workable biodiversity strategy that engages a variety of stakeholders, helping the strategy to succeed. In yet another situation, a community may not have sufficient interest, expertise, or enabling conditions to successfully implement a biodiversity strategy; in these circumstances, the continuing education course could be used to raise awareness, thereby preparing the path for constructing an informed and community-supported biodiversity strategy. Finally, the CE course could be used simply to train local landowners and developers with a keen interest in designing and managing their properties for biodiversity. Thus, a biodiversity workshop could have one or multiple goals, depending on local conditions and target audiences. Below, we list a few CE goals:

1. Provide built environment professionals (e.g. developers, architects, contractors) and landowners with basic information, tools, and examples of ways to conserve and restore natural habitat and promote biodiversity. We hope it will bridge the gaps between developers, landowners, and stated biodiversity planning strategies and/or regulations
2. Empower planners and policymakers to refine or create new policies and strategies to conserve biodiversity
3. Provide landowners and developers, who are already motivated to conserve or restore biodiversity, with basic information, tools, and examples of ways to conserve and restore natural habitat and promote biodiversity. We hope it will create model communities and rural properties of excellence that inspire others to do the same
4. Provide the general public with basic information so that they can evaluate a proposed policy or actual development design as to its positive or negative impact on biodiversity
5. Provide already constructed neighbourhoods with information to 'retrofit' their neighbourhoods.

6. Finally, this course could be used as a 'train the trainer' exercise where participants take the materials and offer the course in other localities.

This participant's manual is really a resource manual that people can take home and further explore at their own leisure. A set of PowerPoint presentations accompanies the resource manual and highlight just a few issues and topics within the manual. A facilitator may want to expand or condense certain PowerPoint presentations, depending on local needs and participants signed up for the course. The course is divided into three parts:

Part 1 discusses key concepts and key players who are working to improve New Zealand biodiversity. It is an introduction to biodiversity and threats to biodiversity – why anybody would want to preserve biodiversity, general discussion about important ecological concepts and New Zealand natural communities – and it contains an overview of land development and how this interfaces with New Zealand policy. Next, it focuses on mechanisms (e.g. conservation easements) and resources (e.g. funding) to help both developers and rural landowners conserve or restore open space. We have also included a broad overview discussion of restoration ecology and principles. We end this first part with a section on policies and sustainable development strategies that have been adopted in the USA and which may be applied to New Zealand. Some of these strategies are relevant to conserving or restoring open space and others suggest different ways to encourage sustainable development.

Part 2 focuses on appropriate steps to take when subdividing or developing a property. It stresses the three phases of a development: design, construction, and post-construction. While the emphasis is on subdividing property, the recommendations are relevant to rural landowners and existing neighbourhoods when they are attempting to restore portions of their properties.

Part 3 is a 1 ½ hour facilitated 'capstone' exercise where participant teams design a subdivision on a land parcel, given certain physical, biological, and regulatory conditions. Teams are not only expected to produce a design but also to address potential issues during the construction and post-construction phases.

Note: A resources and appendix section (at the end of this participant's manual) gives references for further reading and links to resources and contacts where participants can obtain further guidance on creating communities and properties that conserve or restore biodiversity.

The entire course should take about 5 ½ - 6 hours (including introductions, short breaks, and final group exercise) and may be used as a primer for subsequent workshops. There is no way to cover every topic within the course manual during the allotted time, and the accompanying power point should be modified to highlight those topics relevant to the intended audience. For example, if the participants are primarily landowners and developers, the section on financial strategies to conserve or restore open space could be highlighted.

Further, depending on the audience and who is leading the workshop, a customised addendum could accompany the resource manual that shows how the practices described in the guide interface with local biodiversity plans, policies, or regulations. This addendum will help built environment professionals navigate how suggested biodiversity design and management practices fit in with local policies. The addendum will be different from one local authority to the next but would complement information presented at the course. It would also need to be updated from time to time. This addendum, compiled by local presenters, should also highlight local contacts and resources to help landowners conserve or restore biodiversity.

## Overview and check-list

This manual is about one aspect of sustainable and healthy development that meets the modern and revealed needs of plant diversity, wildlife, and ultimately people.

It focuses almost exclusively on the ecology, conservation and restoration of biodiversity. Evidence shows that not only do we need to integrate nature into our living environments - to contribute to the urgent effort required to turn around the looming biodiversity crisis - but actually most people want it!

Ecology is a complex business in which everything is connected. Famously, put another way – ‘there are no free lunches’; but if we make a healthy lunch we are all likely to be happier and more satisfied.

This course manual is a reference to all the things you as a planner, developer, or resident may wish to achieve in an ecologically functional community. It provides many cross-linkages internally and to outside sources of information. It is based on the idea of not only advocating particular actions, but also providing the rationale and ecological understanding behind the action.

Below we provide a checklist of the essential (and bonus) tasks that should be undertaken when constructing a development or subdivision. In many cases, it will not be practicable to implement all of these measures, but every one that is adopted, will enhance the survival, experience and comprehension of nature in your neighbourhood. In the end, since every situation is different, consulting with an experienced ecologist from your region at the beginning of the process will be some of the best advice you can get.

### Pre-construction (design) phase

- Engage a triple (plus) bottom line team (e.g., business person, developer, environmental engineer, ecologist, trans-cultural sociologist, and planner) to look over the initial concept with regards to social, economic, and environmental issues – to identify snags and hurdles and opportunities.
- Consult and engage with affected parties – neighbours, community, local iwi, local government.
- Resource inventory of site and surrounding catchment (landforms, drainage, soils, plants, wildlife, habitat, weeds, animal pests, connectivity, rare species – an asset not a liability).
- Familiarise with policies, protective devices, financial and in-kind incentives that promote or assist with costs of environmental mitigation and enhance biodiversity.
- The hierarchy of measures for protection of habitat or biodiversity is to avoid (disturbing natural areas), mitigate (minimise impacts and restore damaged sites) or remedy (recreate new habitat, offset etc.). Retaining (avoidance) of primary habitat is most crucially important.
- Accommodate values or sensitivities of iwi, other cultural groups and the wider community.
- Allow for indigenous plant and animal needs of food, water, cover and space (on and beyond the site).
- Create a road system that minimises habitat fragmentation.
- Provide for connectivity to the wider catchment.
- Engagement of contractors – carry out ongoing training through whole process to ensure everyone on the team is on the same page.

### Construction phase

- Landscaping palette – use native plants and know the appropriate native plants for the area and for the micro-sites within the development. Protection measures for retained landforms, soils, trees, habitats (on and adjacent to site), and water bodies.
- Strategic control of pest plants and animals.
- Minimise waste and contamination by the three R's (reduce, re-use, recycle).
- Minimise impervious surfaces and high maintenance areas such as lawns.
- Install stormwater treatment trains that incorporate and use natural features and native plants.
- Check the credentials of the landscaping contractor (do they know about eco-sourcing, have good planting technique, and have successful 1-3 yr old projects that you can inspect). Note that landscape designs should be conceptual and reliance should be placed on experienced overseers laying out detailed arrangements during the planting process.

- Allow plenty of time for ordering plants and ideally plant in Spring in frosty or winter-wet places, autumn in dry northern places, and mid summer in wetlands or adjacent to water – build these timelines into the construction plan.

**Post-Construction Phase**

- Implement an ongoing environmental education programme in order to engage residents in the community.
- Securing long-term funding and public support for maintenance of biodiversity and habitat.
- Minimise human impacts and resolve human-wildlife conflicts.
- Ongoing control and local eradication of plant and animals pests and also in surrounding catchment – perhaps with assistance from local government.
- Monitoring of success and employing adaptive management.
- Regular activities to keep the community engaged with the vision.

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## Part One: Key concepts and players: preliminaries

*The challenge in the future is to develop forward-thinking strategies that encourage people towards more sustainable forms of development, to move away from short-term piecemeal planning, highly consumptive waste behaviour, high and increasing demands on energy use, rising infrastructure costs, rising transport demands, greater demands on land and building space, increasing urban human health problems, decreasing environmental quality, neglect of cultural issues and factors, the domination of artificial human environments over natural systems, the decreasing role the natural environment plays in the lives of urban populations, and a lack of awareness and understanding of the significance of natural ecosystems and ecosystem services within urban environments, especially for human well-being.* (Garth Harmsworth, 2004)<sup>1</sup>

### 1.1 Objectives

- ✓ Comprehend what biodiversity is and describe benefits of conserving biodiversity
- ✓ Understand the four major components of wildlife habitat
- ✓ Become familiar with the major New Zealand natural community types
- ✓ Be aware of landowner financial options and funding resources for conserving and restoring open space
- ✓ Understand how current local policies, programmes, and resources promote conservation and restoration efforts
- ✓ Be aware of sustainable development programmes and policies in the USA

### 1.2 Introduction

New Zealand is truly a unique country. Its climate ranges from subtropical to subantarctic and its landforms from mountains and rolling hills to alluvial plains. New Zealand has a land area of about 270 197 km<sup>2</sup> on three main islands (North Island, South Island and Stewart Island) and several smaller surrounding islands: the Chatham Islands, 800 km to the east, the Kermadec Islands to the north, and the subantarctic islands to the south. Based on soil and climatic conditions, New Zealand has been classified into 20 distinct land environment categories<sup>2</sup>.

New Zealand is a biodiversity hotspot with 1865 endemic (i.e. found nowhere else in the world) plants, 63 endemic bird species, 47 endemic skinks/geckos, 2 tuataras, 2 endemic bats, and 4 endemic amphibians<sup>3</sup>. It is also home to a large number of endemic invertebrates, fish, and marine species. Many of these endemic species are threatened by human activities and some are at risk of extinction.

One analysis, using specific criteria, indicates that land suitable for intensive urban or rural development comprises 44% of the whole country<sup>4</sup>. Most agriculture and urban development exists in lowland areas where very little remnant native vegetation remains and is unprotected (see Canterbury Region example, Figure 1). Large numbers of threatened plants and animals

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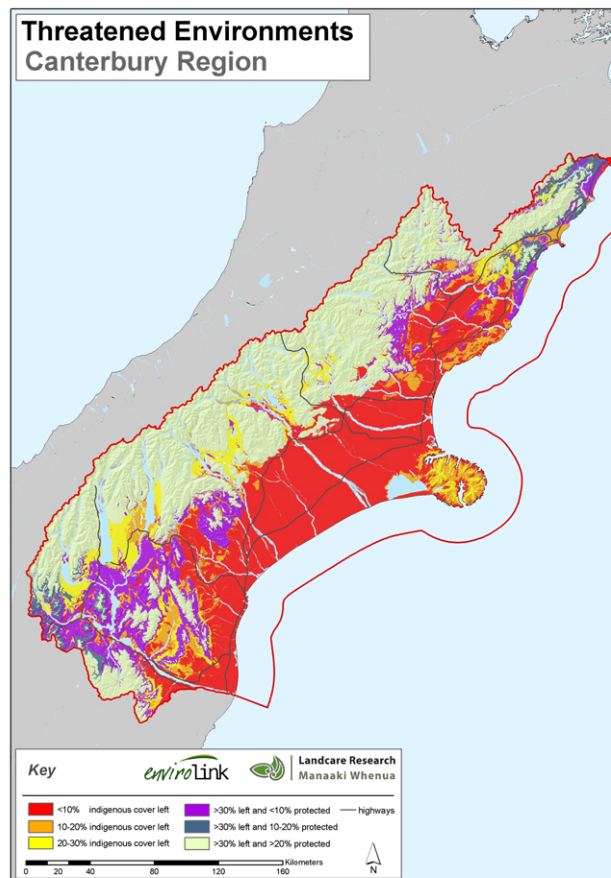
<sup>1</sup> Harmsworth GR 2004. The role of Maori values in Low-impact Urban Design and Development (LIUDD) Discussion paper. Collaborative Learning and LIUDD websites, Landcare Research.  
[https://www.landcareresearch.co.nz/assets/researchpubs/harsworth\\_maori\\_LIUDD.pdf](https://www.landcareresearch.co.nz/assets/researchpubs/harsworth_maori_LIUDD.pdf)

<sup>2</sup> Leathwick J, Morgan F, Wilson G, Rutledge D, McLeod M, Johnston K 2003. Land environments of New Zealand: Technical guide. David Bateman, Auckland, New Zealand.

<sup>3</sup> Biodiversity hotspots – [www.biodiversityhotspots.org](http://www.biodiversityhotspots.org)

<sup>4</sup> Criteria for urban-unsuitable land were: slope/ruggedness, marshes/flood ponding, surface water, indigenous forests, national parks, exotic forests. Criteria for natural habitability were: mean hours sunshine, mean temperatures, number of rainy days, proximity to coast or river, earthquake hazard, proximity to active volcanoes. Source: <http://transurban.co.nz/>

exist in lowland areas<sup>5</sup>; 13 of the 20 land environments occur in cities and almost three-quarters of acutely threatened land environments are found within 20 km of city centres<sup>6</sup>. The take-home message? Conserving and restoring natural vegetation within agricultural areas or near urban areas can have a huge impact on biodiversity in New Zealand.



**Figure 1** Threatened environments within the Canterbury Region. (Source: Susan Walker, Landcare Research)

Countries around the world have identified that various urban and rural development activities are a threat to our environment. Many states and countries have identified (at least) seven threats when accounting for human health, ecosystems, and quality of life. These threats are:

- Alteration / fragmentation/ loss of ecosystems
- Loss of species
- Surface water quality
- Groundwater quantity
- Groundwater quality
- Air quality – ambient
- Air quality – indoor

The design and management of New Zealand's growing communities directly and indirectly affect all of these seven threats. New Zealand is going to grow. According to New Zealand government estimates, New Zealand's population is about 5 356 700 (as of December 2024) and is projected to continue to grow<sup>7</sup>. However, as demonstrated<sup>8</sup>, there are ways to develop that can minimise

<sup>5</sup> Walker RG 2002. Taxonomic and ecological profiles of rarity in the New Zealand vascular flora. *New Zealand Journal of Botany* 40: 73–93.

<sup>6</sup> Clarkson BD, Wehi PM, Brabyn LK 2007. A spatial analysis of indigenous cover patterns and implications for ecological restoration in urban centres, New Zealand. *Urban Ecosystems* 10: 441–457.

<sup>7</sup> Statistics New Zealand – [www.stats.govt.nz](http://www.stats.govt.nz)

impact on our natural resources, particularly plants and animals, while improving our quality of life. 'Win-win' solutions address the financial bottom line while minimising environmental degradation.

### 1.3 Defining conservation and restoration

Many people confuse the terms *preservation* and *conservation or protection*. It is important to understand there are subtle differences between these concepts. In current usage, *preservation* often refers to protecting wildlife and natural habitats in a constant state without account for human requirements. *Conservation* 'implies...management within given social and economic constraints, producing goods and services for humans without depleting natural ecosystem diversity, and acknowledging the naturally dynamic character of biological systems'.<sup>9</sup> For the purposes of consistency, the term *conservation* is typically used throughout this manual, although *preservation* might also be an appropriate term where the objective is to create sanctuaries with little accommodation for human use.

*Restoration* is another term used in this course. In 2002, the Society for Ecological Restoration (SER) ([www.ser.org/](http://www.ser.org/)) defined ecological restoration as 'the process of assisting the recovery of an ecosystem that has been degraded, damaged, or destroyed'. This intentional activity can be rather simple or complex. It may require simply the addition of native plants to an area with a minimal management plan, whereas other situations may call for extensive clean-up and management protocols (e.g. mammalian predator control) that entail more effort. Overall, it requires thoughtful deliberation among a variety of stakeholders. In New Zealand, if we still had the luxury of substantial remnants of original (primary) habitat across the lowland countryside, it would be hugely more economical to protect these systems. But restoration and planting are valuable now when we have lost so much. This can repair lost or damaged habitat by creating buffer zones around protected remnants, removing pests or starting from scratch.

Throughout the manual, the term *wildlife* is interchangeable with the terms *animals* and *fauna*. When we use these terms, we are referring to native New Zealand animal species. Notably, almost all terrestrial mammals in New Zealand are exotic (excluding several bat species) and have been introduced from other countries. We are not promoting the increase of exotic mammal diversity in New Zealand as many of these species (e.g. stoats and possums) have been shown to have major impacts on local indigenous species.

### 1.4 What is biodiversity?

The combinations of different, healthy natural habitats help to create *biodiversity*. Biodiversity is generally defined as the variety of life – across ecosystem, species, and genetic scales. Biodiversity is a global concept but can refer to the number of habitats and species within a local area or region. It is not an exact term and can have various interpretations, but it usually has three components.

- *Habitat diversity* – The Earth has a wide variety of habitats or ecosystems where life exists. Ecosystems are basically interacting associations of microbes, plants and animals with their physical environment within a defined space. Deserts, coral reefs, and tropical rainforests are just a few example ecosystems. Yet, the more humans learn about life, the more we realise the extreme diversity in habitat types.
- *Species diversity* – When people refer to biodiversity, they typically mean species richness. This is the number of different types of plants and animals. Though 1.5 million species have been named, it is estimated the Earth harbours between 5 and 15 million species of plants and animals.
- *Genetic diversity* – This refers to the variety of genetic information contained in all of the individual plants, animals and microorganisms. It occurs within and between populations

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<sup>8</sup> van Roon MR, Knight SJ 2004. Ecological context of development: New Zealand perspectives. Oxford University Press, Melbourne, Australia.

<sup>9</sup> Source: Allaby M 1994. The concise Oxford dictionary of ecology. Oxford University Press.

of species as well as between individual species. For example, there are three different types of kiwi and there used to be 11 types of moa.

In New Zealand we have about 2500 native vascular plants (ferns, conifers and flowering plants). European settlers began importing familiar productive or amenity plants from their continental homelands less than 200 years ago. Now we have in excess of 2000 weed plant species – many escape from gardens into the wild<sup>10</sup>. Many of these exotic species are still spreading and about 13 more are becoming naturalised every year. This is a major threat to our native flora, which gets pushed further back into inaccessible hinterlands. The same is true of animals. New Zealand had no native land mammals until Polynesians brought the rat (kiore) and dog (kuri) here in the last thousand years or so.

New Zealand's biodiversity, measured in terms of number of native species, is relatively small on the world scene, but typical of remote islands. Its importance is, however, disproportionately large, as many of the long-isolated species are ancient lineages that have no close relatives elsewhere in the world, or are regarded as ancestral to more widespread groups. Accordingly, New Zealand is classified as one of the World's biodiversity 'hotspots' ([www.biodiversityhotspots.org](http://www.biodiversityhotspots.org)). It is important to distinguish between *biodiversity* and *species richness*. If we could suddenly replace all our native plant species with exotics then total species richness would be greater than in primordial New Zealand (>20 000 exotics versus about 2500 natives). Thus, local species richness has increased but world biodiversity will have declined by 2500 very important species. Packing in more species doesn't increase biodiversity – it merely spreads globally common species to more places and constricts local diversity. Biodiversity is thus a measure of the variety of species or ecosystems found naturally in an area (i.e. indigenous or native) or found nowhere else in the world (i.e. endemic)<sup>11</sup>.

## 1.5 Benefits to conserving and restoring biodiversity



*Podocarp forest, West Coast, New Zealand Photo: Mark Hostetler*

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<sup>10</sup> Weeds database – <https://www.massey.ac.nz/about/colleges-schools-and-institutes/college-of-sciences/our-research/themes-and-research-strengths/plant-science-research/new-zealand-weeds-database/>

<sup>11</sup> Excerpted from: Ignatieva M, Meurk C, Van Roon M, Simcock R, Stewart G 2008. How to put nature into our neighbourhoods – application of Low Impact Urban Design and Development (LIUDD) principles, with a biodiversity focus, for New Zealand developers and homeowners.

What do you see you when look at a forest? The Environmental Literacy Council ([www.enviroliteracy.org](http://www.enviroliteracy.org)) sees many things:

*A forest, for example, may be at one and the same time a place of great beauty; a natural resource critical to the health and well-being of neighbouring communities; a local ecosystem, supporting rich plant and animal life; and a vital component in the planet's great biogeochemical cycles for regulating global climate.*

This description helps show the diverse and interconnected value of natural habitats. Every habitat is unique and offers many benefits. In a general sense, these benefits can be broken into three distinct yet overlapping categories: ecological/environmental, social/political, and economic. For example, district, regional, and national regulations are used to control activities such as land use. Though these regulations may be created for good reason, achieving compliance can often be difficult. It is no secret that New Zealand's population continues to grow, urbanisation continues to sprawl, and the natural environment, including its goods and ecosystem services, is being constrained and degraded as a result. Regulations that help to manage the balance of environmental, social, and economic systems across the country will likely grow in magnitude and complexity over time to address these effects. If the built environment and agricultural industries fail to get ahead of the curve now, compliance will be costly. Innovators that keep up with these trends will be leagues ahead of their competition and might even play a role in the direction that regulation takes. In the near future, it is very possible that green building and development will no longer be a niche market, but the very foundation upon which New Zealand's 21<sup>st</sup> century human habitats are built. Several benefits exist to conserving and restoring biodiversity, and they include:

- Ecological and environmental benefits
- Social and human health benefits
- Economic benefits

### 1.5.1 Ecological and environmental benefits

Natural areas provide a wide variety of critical ecosystem 'services'. These services are highly valued economically as well. However, they are rarely bought, sold, or internalised into the cost of consumer goods and services. They are available free of charge. Yet once we damage the ability of natural areas to provide these services, high costs to society are realised. Think of these services as the life support system for all species on Earth, including humans. In a scientific paper published in the May 1997 issue of the journal *Nature*, the economic value of the 12 major ecosystem services and the 5 major ecosystem goods was estimated to be approximately US\$16–54 trillion, with an average of US\$33 trillion annually<sup>12</sup>. The paper additionally estimated the global gross national product to be US\$18 trillion annually.

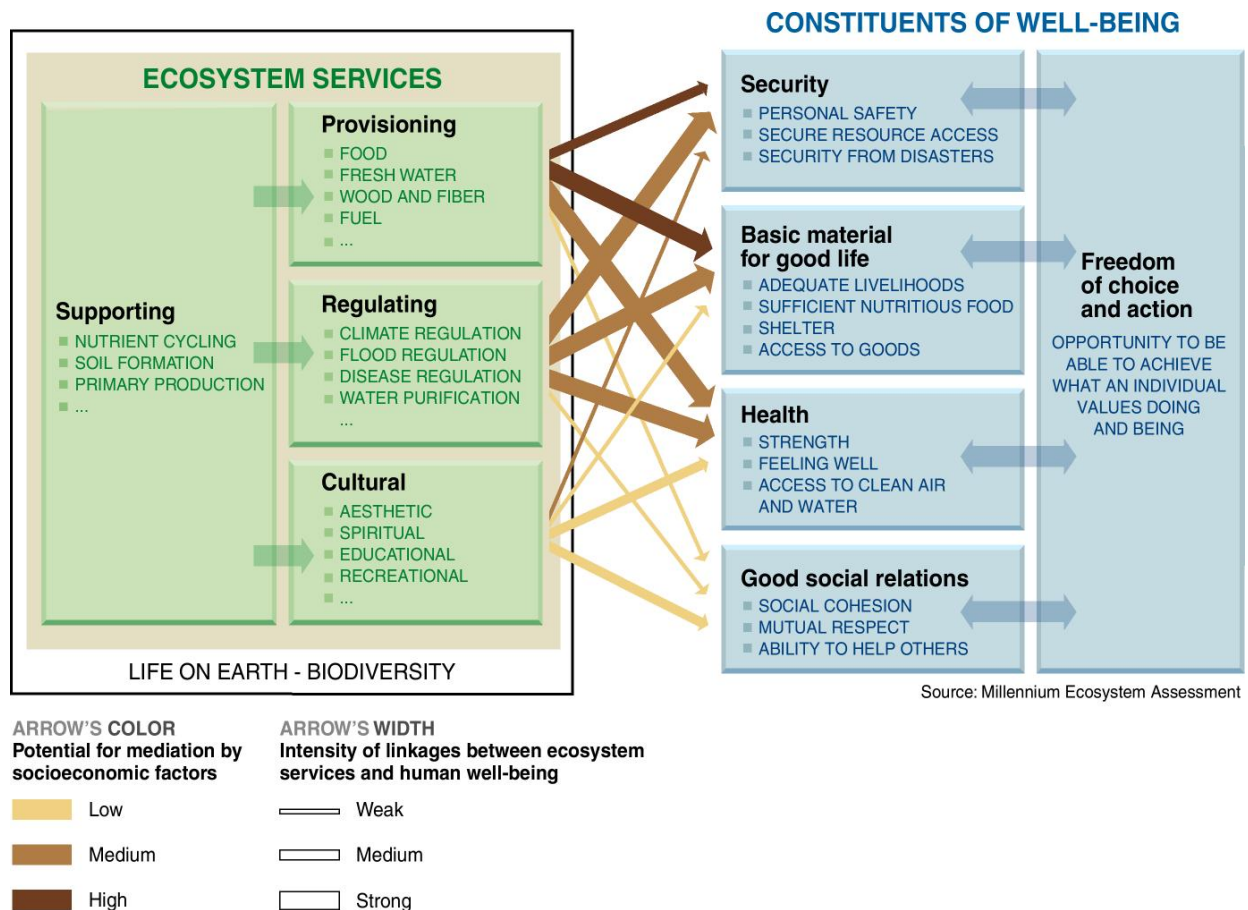
Several such examples can be found in New Zealand. In the Nelson/Tasman region, ecosystem services to the regional economy was estimated by the New Zealand Centre for Ecological Economics to be over NZ\$1 billion per year<sup>13</sup>. This is over half the value of gross regional economic production measured from local statistics. In addition, the five big economic sectors – horticulture, tourism, agriculture, seafood, and forestry – rely directly on local natural resources and healthy ecosystems, and they are especially vulnerable to biosecurity threats (e.g. invasive plants and animals).

Many linkages occur between ecosystems and human well-being (Figure 2). Hearts and minds are a vital part of the conservation imperative.

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<sup>12</sup> Costanza R, d'Arge R, de Groot R, Farber S, Grasso M, Hannon B, Limburg K, Naeem S, O'Neill RV, Paruelo J, Raskin RG, Sutton P, van den Belt M 1997. The value of the world's ecosystem services and natural capital. *Nature* 387: 253–260.

<sup>13</sup> As reported in Nelson Biodiversity Strategy 2007 to 2009 report: [www.nelsoncitycouncil.co.nz](http://www.nelsoncitycouncil.co.nz)



**Figure 2** Linkages between ecosystem services and human well-being  
(Source: Millennium Ecosystem Assessment synthesis report released 23 March 2005)

### A summary of the Earth's primary ecosystem services<sup>14</sup>

#### Ecosystem services

Ecosystem services are the benefits people obtain from ecosystems. These include provisioning and regulating services that directly affect people and the supporting services needed to maintain other services. Many of the services listed here are highly interlinked (primary production, photosynthesis, nutrient cycling, and water cycling, for example, all involve different aspects of the same biological processes).

- **Supporting services** – Those that are necessary for the production of all other ecosystem services. They differ from provisioning, regulating, and cultural services in that their impacts on people are often indirect or occur over a very long time, whereas changes in the other categories have relatively direct and short-term impacts on people. (Some services, like erosion regulation, can be categorised as both a supporting and a regulating service, depending on the timescale and immediacy of their impact on people.)
- **Provisioning services** – Products obtained from ecosystems
- **Regulating services** – Benefits obtained from the regulation of ecosystem processes

<sup>14</sup> Excerpted and adapted from the *Millennium Ecosystem Assessment synthesis report* (released 23 March 2005, pp. 80–81) – [www.millenniumassessment.org](http://www.millenniumassessment.org)

<b><i>Supporting services</i></b>	<b><i>Details</i></b>
<b>Soil formation</b>	Because many provisioning services depend on soil fertility, the rate of soil formation influences human well-being in many ways
<b>Photosynthesis</b>	Photosynthesis produces oxygen necessary for most living organisms
<b>Primary production</b>	The assimilation or accumulation of energy and nutrients by organisms
<b>Nutrient cycling</b>	Approximately 20 nutrients essential for life, including nitrogen and phosphorus, cycle through ecosystems and are maintained at different concentrations in different parts of ecosystems
<b>Water cycling</b>	Water cycles through ecosystems and is essential for living organisms

<b><i>Provisioning services</i></b>	<b><i>Details</i></b>
<b>Food</b>	This includes the vast range of food products derived from plants, animals, and microbes
<b>Fibre</b>	Materials included here are wood, jute, cotton, hemp, silk, and wool
<b>Fuel</b>	Wood, dung, and other biological materials serve as sources of energy
<b>Genetic resources</b>	This includes the genes and genetic information used for animal and plant breeding and biotechnology
<b>Biochemicals, natural medicines, and pharmaceuticals</b>	Many medicines, biocides, food additives such as alginates, and biological materials are derived from ecosystems
<b>Ornamental resources</b>	Animal and plant products, such as skins, shells, and flowers, are used as ornaments, and whole plants are used for landscaping and ornaments
<b>Fresh water</b>	People obtain fresh water from ecosystems and thus the supply of fresh water can be considered a provisioning service. Fresh water in rivers is also a source of energy. Because water is required for other life to exist, however, it could also be considered a supporting service

<b><i>Regulating services</i></b>	<b><i>Details</i></b>
<b>Air quality regulation</b>	Ecosystems both contribute chemicals to and extract chemicals from the atmosphere, influencing many aspects of air quality
<b>Climate regulation</b>	Ecosystems influence climate both locally and globally. At a local scale, for example, changes in land cover can affect both temperature and precipitation. At the global scale, ecosystems play an important role in climate by either sequestering or emitting greenhouse gases
<b>Water regulation</b>	The timing and magnitude of runoff, flooding, and aquifer recharge can be strongly influenced by changes in land cover, including, in particular, alterations that change the water storage potential of the system, such as the conversion of wetlands or the replacement of forests with croplands or croplands with urban areas
<b>Erosion regulation</b>	Vegetative cover plays an important role in soil retention and the prevention of landslides
<b>Water purification and waste treatment</b>	Ecosystems can be a source of impurities (e.g. in fresh water) but also can help filter out and decompose organic wastes introduced into inland waters and coastal and marine ecosystems and can assimilate and detoxify compounds through soil and subsoil processes
<b>Disease regulation</b>	Changes in ecosystems can directly change the abundance of human pathogens, such as cholera, and can alter the abundance of disease vectors, such as mosquitoes
<b>Pest regulation</b>	Ecosystem changes affect the prevalence of crop and livestock pests and diseases
<b>Pollination</b>	Ecosystem changes affect the distribution, abundance, and effectiveness of pollinators
<b>Natural hazard regulation</b>	The presence of coastal ecosystems such as mangroves and coral reefs can reduce the damage caused by hurricanes or large waves

Now, loss of biodiversity, in terms of habitat diversity, can affect ecosystem services. For example, the loss of coastal ecosystems (being replaced with farmland or cities) would result in increased damage caused by tidal surges. With homes built right on the coast, no buffer (estuaries or dune ecosystems) exists to protect human development from tidal surges. What about loss of biodiversity in terms of species diversity? Could we not have exotic species in an area (that have replaced natives) and they provide the same ecosystem service? For example, many exotic species can effectively remove nutrients from water in a lake (a regulation service, purifying water). This may be true but, thinking globally, homogenising the species composition around the world can have many unfortunate consequences, such as limiting our genetic resources and ability to create new medicines and biochemicals.

Plus, many intricate connections exist between the physical environment and local, native organisms. Replacing the natives with exotics may have unforeseen consequences. For example, pollination services of animals are much more resilient if there are a number of different species providing this service. Look at the reliance of honeybees for pollination of fruits and vegetables in New Zealand and America – the honeybee population in America is currently being decimated by a number of factors, including the varroa mite and pesticides. The New Zealand Government and the bee industry have continued to monitor for outbreaks of varroa and methods have been developed for building resilience to infestation<sup>15</sup>. In America, citrus farmers are losing money as their trees are not pollinated well by honeybees; native insect pollinators in the area cannot take over this pollination service because their population numbers are inadequate. The quantity and diversity of local insect pollinators has been reduced in America because of local applications of pesticides and habitat destruction. Without native pollinators to take up the slack, a decrease in fruit production has occurred.

### 1.5.2 Social and human health benefits

- *Natural areas have aesthetic, spiritual, healing, and ethical value.* The beauty of New Zealand's natural areas – its forests, beaches, and urban open space – provides residents and tourists with a resource for relaxation and reflection. Valuable natural areas can be as small as an individual yard or a neighbourhood small park. Creatively designed gardens and native landscaping can bring a bit of the natural environment into our urban surroundings. But it is important to remember that the best natural areas are those designed to accommodate both humans aesthetically and wildlife functionally. Diversity is a major theme in New Zealand's natural history. Prior to European settlement the tangata whenua utilised the natural resources of the world as they found it – with the exception of imported kumara, taro, yams, dog and rat as sources of carbohydrate and protein. Initially exploitation resulted in extinctions of the lumbering and slowly reproducing animals, but over time a new balance was achieved and sustainable harvesting of resources was practised. From this nexus arose the traditional Māori culture. Most plants and animals of Aotearoa–New Zealand had been given names, and their attributes for food, fibre, building material, and rongoa (medicinal plants) were well known. As such they were taonga or treasures essential for survival. For instance, raupo pollen was collected and used to make a protein-rich and sweet cake, while the foliage and stalks were bundled together to make thatching and temporary rafts. New Zealand has a distinctive mix of plants, animals, geography, and climate. By conserving and restoring biodiversity in and around cities, developers across New Zealand have an opportunity to create a true sense of place. This is a valuable commodity in a built environment that is becoming ever more homogenised.
- *New Zealanders want nature in their lives:* Several surveys in New Zealand have shown that contrary to the loudest voices, the large majority of citizens want more native plants and wildlife in their neighbourhoods<sup>16</sup>.
- *Interaction with natural areas promotes better human health.* A recent study published in the May 2003 issue of the journal *Environment and Behavior* found that nearby natural areas protect

<sup>15</sup> Ministry of Environment. Our Land -2024, website <https://environment.govt.nz/publications/our-land-2024/> (accessed 24 Feb 2025).

<sup>16</sup> Craig JL 2005. Metapopulations with people. Greening the city: bringing biodiversity back into the urban environment. In: Dawson M ed. Proceedings of the Royal New Zealand Institute of Horticulture, 2003. Pp. 23–28.

children from the impact of life stress. Furthermore, this protective buffering intensifies with increasing stress levels. In a review of extensive existing literature, the authors also state ‘time spent in contact with the natural environment has been associated with better psychological well-being, superior cognitive functioning, fewer physical ailments, and speedier recovery from illness’<sup>17</sup>. On the other hand, one has to be careful about which plant species are grown near homes as the pollen of some exotic plant species are known allergens (e.g. silver birch, plane trees, and exotic grasses) and can affect human health<sup>18</sup>.

- *Natural areas provide shared green space for humans to interact and recreate.* Residential communities can create a strong sense of place by incorporating green space into their designs. This allows residents an opportunity to socialise and watch wildlife in its natural setting. In a study published in the September 2003 issue of the journal *Society and Natural Resources*, sense of place meanings, attachment, and satisfaction were affected by not only social constructions but also the landscape attributes of the physical environment<sup>19</sup>.
- *Natural areas offer unparalleled opportunities for learning.* Natural areas are often used to educate people about their environment and human history.

### 1.5.3 Economic benefits

- *Healthy natural areas allow for tourism and recreation.* The country’s tourism industry provides a substantial income for New Zealand’s economy, billions each year<sup>20</sup>. Yet tourism, especially ecotourism, is heavily influenced by the quality and quantity of countrywide natural areas and depends on an authentic ‘clean green’ imagery. These natural areas provide places for tourists to enjoy New Zealand’s natural resources.
- *Inland natural areas sustain the health of coastal natural areas.* New Zealand’s commercial seafood harvest generates billions each year<sup>21</sup>. Marine ecosystems such as salt marshes, mangroves, and estuaries support the organisms New Zealand’s fisheries depend on (e.g. often juvenile stages of commercial fish species occur in estuaries). Yet these natural communities are also dependent on and affected by nutrients and organic material from inland landscapes.
- *Natural areas reduce the urban heat island effect of developed land.* Areas within cities can be as much as 12°C hotter than the surrounding natural landscape. When buildings and paved surfaces replace trees and vegetation, the surrounding air warms. This warming dramatically increases the levels of smog-forming ozone. Heat islands also create their own weather causing thunderstorms and increasing the potential for flooding and erosion. The economic costs of heat islands are high as a result of air pollution and increased energy use for air conditioning among other things.
- *Preserved natural areas can increase property values.* Most homeowners view healthy natural communities within close proximity to homes as aesthetically pleasing. A recent New Zealand study found that Auckland property values increased with a scenic view of open space<sup>22</sup>. Additional studies on the economic value of green space can be found at:
  - *The Economic Benefits of Parks and Open Space* (by The Trust for Public Land at <https://www.tpl.org/resource/economic-benefits-parks-and-open-space-1999>)
    - ‘The home-buyer, speaking...through the marketplace, appears to have demonstrated a greater desire for a home with access...to permanently protected land, than for one located on a bigger lot, but without the open-space amenity.’

<sup>17</sup> Wells NM, Evans GW 2003. Nearby nature: A buffer of life stress among rural children. *Environment and Behavior* 35: 311–330.

<sup>18</sup> Spellerberg IF, Eriksson NE, Crump V St. A 2006. Silver birch (*Betula pendula*) pollen and human health: problems for an exotic tree in New Zealand. *Aborigiculture and Urban Forestry* 32: 133–137.

<sup>19</sup> Stedman RC 2003. Is it really just a social construction? The contribution of the physical environment to sense of place. *Society & Natural Resources* 16: 671–685.

<sup>20</sup> Source: <https://www.tourismnewzealand.com/>

<sup>21</sup> Source: <https://www.seafood.co.nz>

<sup>22</sup> Source: Samarasinghe OE, Sharp B 2008. The value of a view: a spatial hedonic analysis. Landcare Research Technical Report.

- 'Rank of open space/parks/recreation among factors used by small businesses in choosing a new business location: One'
    - 'Percentage of Denver residents who in 1980 said they would pay more to live near a greenbelt or park: 16%. Percentage who said so in 1990: 48%.'
  - Economic benefits of green infrastructure (links about the economic benefits of green infrastructure available at <https://www.epa.gov/green-infrastructure>)
  - *Saving Land Lowers Taxes* (by Robert Levite <https://www.whiteoaktrust.org/wp-index.php/saving-land-lowers-taxes/>)
    - '[Preserved green space creates an] increase in [property] valuation [that] runs from 6% or more in rural areas to as much as 40–50% in urban areas and the increased value can affect homes as far away as ½ mile [c. 1 km] from the preserved open space.'
  - *Economic Impacts of Protecting Rivers, Trails, and Greenway Corridors: A Resource Book* (by the Rivers, Trails and Conservation Assistance of the National Park Service at [https://nacwa50report.org/Content/documents/G3\\_R7\\_EconomicImpactsOfProtectingRivers-1995.pdf](https://nacwa50report.org/Content/documents/G3_R7_EconomicImpactsOfProtectingRivers-1995.pdf))
    - This is an excellent clearinghouse detailing the economic benefits of preserving greenspace. The extensive statistics and survey results are too extensive to include here and we encourage you to visit the website link shown above for more information.
- *Conserving natural habitats can decrease irrigation and stormwater costs.* Many of New Zealand's native plants have adapted to the country's annual cycling of wet and dry seasons<sup>23</sup>. By reducing the amount of formal landscaping and conserving natural areas, developments can reduce or eliminate the need for supplemental irrigation and stormwater management. In particular, to carry water, the costs for piping can be much more expensive to build and maintain than natural treatment<sup>24</sup>.
  - *Taking advantage of established land use options can provide direct cash payments or other economic benefits.* Options such as conservation covenants, land donations, or land sales can preserve natural areas in perpetuity while providing economic incentives to landowners. For New Zealand examples, see [www.ge2.org.nz/](http://www.ge2.org.nz/).
  - *Some municipalities and organisations offer financial incentives for restoring or conserving natural areas.* Several organisations help landowners to conserve and restore property by offering money or free advice. NZ Landcare Trust, Queen Elizabeth II National Trust, The Department of Conservation's Nature Heritage Fund, and Ngā Whenua Rahui have some money and resources to help landowners.
  - *Can speed up resource consent.* In some situations, conserving natural resources in a site plan for a subdivision can speed up the resource consent process because it coincides with what city or regional councils are looking for and actively encouraging. For example, it can reduce the number of requests for 'further information' from a council, shorten council hearings, and potentially avoid appeals to the Environment Court.
  - *Residential communities with preserved natural areas differentiate themselves from the competition.* Developers can gain valuable promotion and advertising opportunities from conserving natural areas within their communities. A 1995 study by American LIVES Inc., a San Francisco based marketing and research firm, showed that homebuyers will pay more for amenities such as natural green space with walking and biking paths. An example of a development group in New Zealand promoting and marketing itself as environmentally focused is Te Rūnanga o Ngāi Tahu <https://ngaitahu.iwi.nz/te-runanga-o-ngai-tahu/our-work-pou/strategy-and-environment/environment/>.

<sup>23</sup> Note that some exotic plants are preadapted to local climate and soil conditions and can do quite well (some even too well and escape into natural areas). However, all else being equal, many flower beds, rose gardens, and fine turfs require more irrigation and extra fertilisers than native shrubbery.

<sup>24</sup> van Roon M, Knight S 2004. Ecological context of development. New Zealand perspectives. Oxford University Press, Melbourne, Australia. P. 244.

## 1.6 The four major components of habitat for animals

All animals have a set of four basic requirements for survival. These major requirements make up all of the wildlife habitats around the world. In a sense, the built environment is wildlife habitat for humans. We are animals after all! As we learn more about the way natural communities function, we gain a better appreciation of the similarities between our needs and those of the other species with which we share the Earth.

### 1.6.1 Exercise on habitat for animals

- ✓ As you view the following slides, can you name the four major components of a functional habitat for wildlife and make a comparison with human needs?

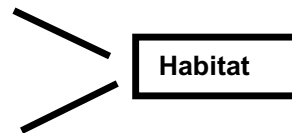
1. \_\_\_\_\_
2. \_\_\_\_\_
3. \_\_\_\_\_
4. \_\_\_\_\_

### 1.6.2 Habitat selection by animals

Looking at a piece of land through our eyes as humans is much different to what another animal species sees. Imagine what a small frog 'sees' as prime habitat versus a human. Although both require food, water, cover, and space, these basic requirements are much different between the two species. Not often will you see a human wallowing in the mud waiting to catch an unsuspecting insect!

**All animals require:**

- Food
- Water
- Cover / Shelter
- Space



Now think about the many different types of animals found in New Zealand. Insects, fish, reptiles, amphibians, and birds have a myriad of different wildlife habitat requirements. It would take an enormous effort to learn about every species' habitat requirements. In the paragraphs below, we do not attempt to review even basic habitat requirements for any given species. Instead, we point out a few basic ecological concepts that have some bearing on evaluating land for wildlife habitat:

- Generalist vs specialist
- Big vs small
- 'Needs' during different stages of life
- Metapopulations and wildlife habitat

#### Generalist vs specialist

Animals that are generalists are species that will eat just about anything and live in a variety of habitats. A generalist can adapt to new food sources and changing systems. Think about house sparrows and starlings. These exotic birds are found throughout New Zealand and are doing quite well in human-impacted areas. They seem to hold their own or even flourish when humans come into an area, being able to exploit new food sources (e.g. food waste and seed feeders) and find new shelter areas (e.g. homes).

Specialists, on the other hand, are much more specialised in their food and shelter requirements. They will sometimes only eat a few types of food and live in only one type of habitat. They do not adapt well to changes in the habitat and will go extinct locally (i.e. extirpated) when their habitat changes. Many of our endangered or threatened species tend to be specialists. Examples include the black robin (*Petroica traverse*), kākāpō (*Strigops habroptilus*), and the striped skink (*Leiopisma striatum*). Thus, when evaluating a piece of property, conserving on-site habitat critical to a specialist is important as these animals tend to be impacted the most when humans move in.

### Big vs small

Intuitively big animals need much more space than small animals. Larger animals operate at broader scales than smaller species and need more space to meet their daily requirements. This roaming area is called its home range. A small fantail can spend its entire lifetime in somebody's backyard (Figure 3). A harrier hawk (Figure 4) can roam over hundreds of miles looking for food and mates. The space needs to be large enough so wildlife can meet their daily requirements in terms of food, cover, and water and can successfully raise their young.



**Figure 3** *Small bird: fantail. Photo: Landcare Research*



**Figure 4** *Big bird: harrier hawk. Photo: Landcare Research*

### Box 1 Habitat selection: A bird's-eye view

If a hawk appears in a residential neighbourhood, it is there not only because of what is within that neighbourhood, but also because of what surrounds the neighbourhood. At each scale (yard, neighbourhood, town) the hawk is responding to certain habitat structures. Within the yard, it may be responding to large trees in which to nest or roost. In the neighbourhood, it could be the amount of forested area and open space. Forested areas provide roosting spots and open spaces provide areas to catch rodents. At the scale of the town, a hawk also responds to the amount of forested versus open areas, but it does this within a much larger area. One side of town may have more open areas and more prey items than another. The hawk may prefer this side of town. In this example, the private garden, neighbourhood, and town form the range of scales at which the hawk responds to objects within a landscape. Each scale is an important factor determining whether the hawk locates itself in a particular area.

Different bird species respond to different objects within a landscape. These objects can be trees, grass, rock outcrops, rivers, shrubs, etc. The type of object a bird prefers is dependent on its natural history – what it eats, what it needs for nesting, and what it needs for shelter. For example, one bird species could prefer dense tree patches while another prefers flowering plants on the edges of tree patches. Some prefer woods along streams (riparian habitats) while others prefer natural open fields. Even the actual buildings or the wide variety of landscaped gardens in a neighbourhood could provide suitable habitat for some bird species.

The structure of habitats across ranges of scale, the size of objects within each landscape scale, and the size of animal species are all interrelated. Intuitively, the size of different species often limits the scales at which each can respond to habitat structure even if they share a need for similar landscape objects. Let's say two birds, a starling and a hawk, like open areas with a few trees. The smaller bird (starling) may be attracted to several small front gardens. The larger bird (hawk) may prefer large expanses like golf courses. While they both respond to open space with a few trees, it is ultimately the size of the bird that determines the scale at which it responds to habitat features.

Thus, when conserving habitat for a harrier hawk, one has to think about hundreds of hectares of land. A small patch of open space is not enough for a harrier hawk, but it may be fine for a smaller animal. In many instances, it is important to connect various natural areas to permit animals with large home ranges to travel across the landscape. These natural connectors are called wildlife corridors; in the case of New Zealand (where introduced, terrestrial, non-flying mammals are not of conservation value), connectors could be viewed more like 'stepping stones' than continuous corridors. However, continuous corridors may be important for our crawling creatures such as native frogs, geckos, and skinks. These issues are discussed in more detail later in this manual. Ecological corridors are important as they allow animals to traverse a landscape that is riddled with barriers such as roads, cities, and grazed pastures.

### **'Needs' during different stages of life**

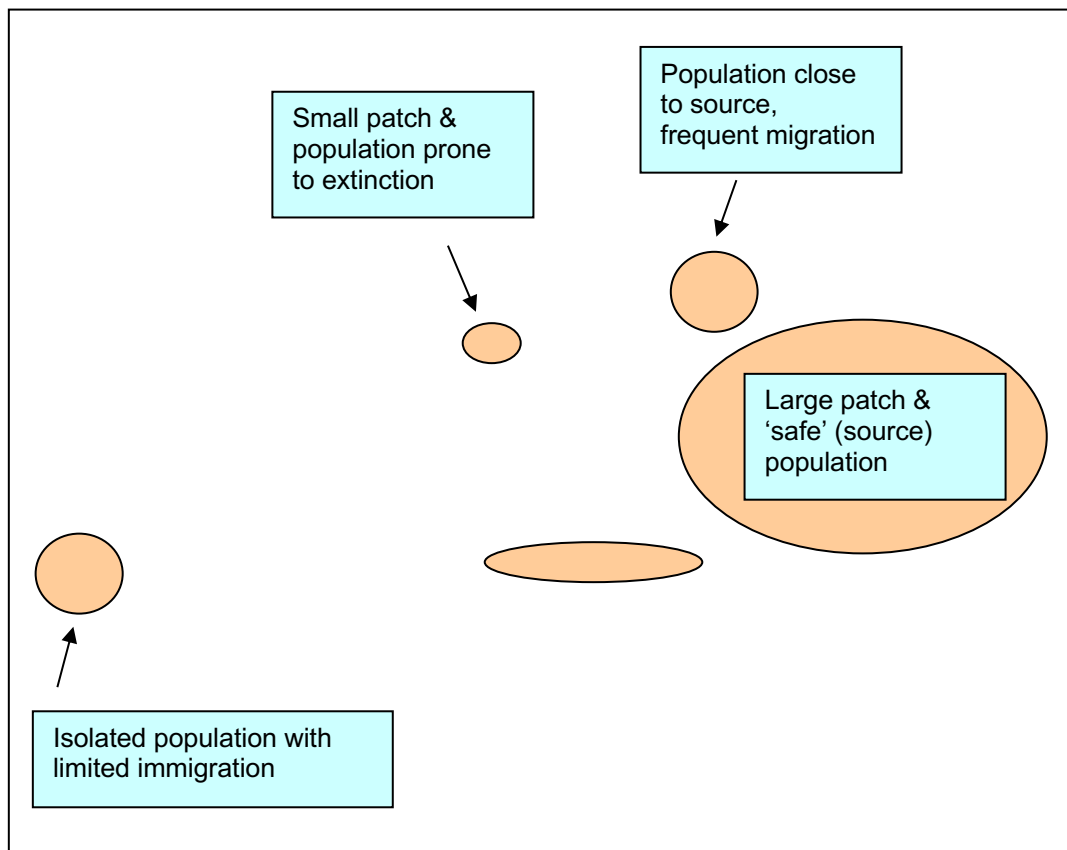
During different periods of an animal's life, it may have different requirements for food, water, cover, and space. For example, birds may have vastly different requirements when breeding than when they are migrating or wintering in an area. Some bird species only nest in dense wooded areas to keep their nests hidden from predators while primarily catching insects to feed their young. However, outside the breeding season, these same birds can be found in shrubby, open areas feeding on a variety of food items including fruits and seeds. After breeding, many birds disperse from their natal site looking for new areas that provide food and shelter. For birds that are dispersing, many urban sites that may not be appropriate for breeding could serve as 'dispersal sites' where birds can feed and rest when searching for new habitat. In addition, urban sites can serve as foraging areas for birds that visit the city looking for food but breed elsewhere. One example includes bellbirds that forage in Christchurch but breed on the slopes of the Port Hills and surrounding Banks Peninsula. Further, New Zealand does not have many birds that migrate between the North and South islands, but there are a few. Birds that migrate within New Zealand include the South Island pied oystercatcher (*Haematopus ostralegus*), which breeds on South Island riverbeds, farmland, and coasts and winters on the North Island. The wrybill plover (*Anarhynchus frontalis*) breeds near braided rivers in the foothills of the Southern Alps, then flies to tidal harbours in the North Island or the north of the South Island. Urban and rural areas can serve as 'stopover sites' for birds to rest and feed. Several other species migrate short distances around New Zealand and many species can use small natural remnants of vegetation as 'stepping stones' to move across the landscape. Some birds nest in New Zealand during the summer but return to an oceanic life or to another country (e.g. the banded dotterel, *Charadrius bicinctus*, winters in Australia).

In summary, a particular property can serve as habitat for animals during different times of the year. A patch of woods may be a breeding area for some animals while at other times of the year it may serve as a stopover site or wintering site. In many cases, the property may serve primarily as a 'connector' between natural areas – an important role to permit the movement of animals.

### **Metapopulations and wildlife habitat**

The health of animal populations is a complex interaction of separate populations within a given region. In its most simplified version, metapopulations are discrete groups of animals that are separated by some distance (Figure 5). Occasionally individuals from one group can migrate to another group. These 'metapopulations' are essential to maintain healthy regional populations. The land matrix between separate populations is important because if it is not conducive for travel, then animals cannot disperse from one area to the next; thus, urban and rural landscapes that are between natural areas can be designed and managed to promote dispersal. One reason these separate but somewhat connected populations are important is the resilience to catastrophic disturbances that increases as a result of their interactions. Natural disturbances, such as fire, flood, diseases, and storms, can wipe out individuals from one area. After this disturbance, individuals from the other populations can recolonise this area. If the entire population of a species was located in one area, a disease epidemic or other natural disaster could wipe out the entire species. Separate populations guard against this scenario – kind of like 'not putting all your eggs in one basket'. Also, the occasional mixing of genes between populations prevents inbreeding problems when groups become small and isolated. Thus, a piece of property may serve as an important metapopulation area, especially if it is connected to other habitats in the area.

It has been noted that many grassland and riverbed species are being squeezed between agricultural or urban intensification, on the one hand, and competition from dense swards of exotic grasses, forbs and shrubs in rough field or road borders, on the other. Some have retreated to environmentally stressed rock ledges, but this is not enough for their long-term survival and so there is an opportunity in the urban context. Rock gardens scattered through a neighbourhood could harbour some of these now rare herbaceous species – as can some wastelands like gravel pits and demolished industrial sites. The seeds and insects (and possibly even the lizards) that feed on the plants might travel between these small habitat islands thereby connecting them as a metapopulation. For the lizards to make the journey safely through a gauntlet of cats and rodents, corridors of rocks would need to be available. Some plant lists for such rock garden micro-habitats are listed in later sections.<sup>25</sup>



**Figure 5** A cluster of populations of various sizes and degrees of isolation. Together these populations comprise a metapopulation as they are all part of an interbreeding group even though some of component populations will share genes more than others<sup>26</sup>.

## 1.7 Natural communities in New Zealand

New Zealand's growth is rapidly converting the country's natural communities into agricultural and urban areas. Natural community types include ecosystems like forests and scrubland. Even unconverted areas can be harmed when land becomes fragmented. For example, pollution from developed areas can be distributed to natural areas of a catchment. This will result in habitat change that could impact animals and plants. Developed and rural areas can be designed and managed in ways to minimise impact on natural habitat.

Overall, understanding and recognising the different types of natural communities in New Zealand is important because when conserving or restoring land one has to recognise what the land looks like in

<sup>25</sup> See also <http://lincolnevirotown.org.nz/wp-content/uploads/2019/04/LET-Native-planting-guide-large-file-2019-WEB.pdf>

<sup>26</sup> Adapted from: Ignatieva M, Meurk C, Van Roon M, Simcock R, Stewart G 2008 How to put nature into our neighbourhoods – application of Low Impact Urban Design and Development (LIUDD) principles, with a biodiversity focus, for New Zealand developers and homeowners.

its natural state. Below, we discuss threats to natural communities, why they are important to conserve or restore, and give a brief overview of the different natural community types found in New Zealand.

### 1.7.1 Threats to our natural communities

Many plant and animal species are threatened by habitat loss. Habitat is generally defined as the area in which an organism lives. Some species require relatively undisturbed areas in which to live. As mentioned previously, because many of our impacts are focused on low-lying areas, many of our plants and animals adapted to lowlands are in danger of becoming extinct from four main threats:

- *Land conversion* – Not long ago, the largest threat to New Zealand's natural communities was conversion to farms and tree plantations. Today, urban development is another form of land conversion. Whereas farming and forestry are somewhat reversible, the concrete and asphalt of urban development are essentially permanent. Development poses a large threat to dryland communities and even wetlands that have been afforded more legislative protection and are less desirable for development. Ironically, the protected wetlands are often damaged by runoff from adjacent drylands.
- *Habitat fragmentation* – The process of land conversion ultimately fragments the land and natural areas become smaller and separated by larger and larger distances. Natural patches embedded in a matrix of urban and agricultural areas are at greater risk to human activities than land that is not fragmented. Many endemic and native species find it difficult to persist in such fragmented landscapes.
- *Invasive exotic species* – Plants and animals that are not native to New Zealand and pose a major threat to natural communities are called invasive exotic species. Disturbed areas, such as urban areas and farmland, are easily colonised by invasive exotics, permanently altering New Zealand's natural communities. Because they use resources typically available to native species, introduced species often outcompete natives and force them from their natural communities. In particular, introduced mammals, such as rats and possums, are decimating native bird populations because they prey on young birds.
- *Water use and runoff* – Agricultural and urban development has progressed at the expense of New Zealand's water supplies. Underground water and surface water (e.g. lakes, reservoirs, and rivers) provide valuable drinking water for all of New Zealand's residents. Yet human activity has threatened the quantity and quality of this precious resource. Additionally, there is a close interdependence among natural communities connected through water flows. Degradation and pollution to a small dryland area can have a profound affect on downstream ecosystems. Urban development and cultivated rural areas typically have limited vegetation to capture rainfall and have increased amount of impervious surfaces that limit the amount of water that can percolate into the ground. This disrupts the water cycle in four major ways. All four are highly interdependent and act to magnify the affects of each other:
  - *Runoff peak discharges are higher.* This leads to increased erosion and downstream flooding.
  - *Pollutant loads in runoff are higher.* This can contaminate potable water and kill aquatic life in downstream waters as nutrients such as nitrogen and phosphorus decrease the amount of oxygen available to fish in a process called eutrophication.
  - *Overall runoff volumes are higher.* When impervious surfaces increase, stormwater runoff volume also increases as the water is unable to infiltrate the soil. One recent estimate states high-density urban-area stormwater runoff may increase as much as 19-fold compared with non-urban areas such as forests.
  - *Deep aquifer and ground recharge is lower.* This directly threatens both the quantity and quality of New Zealand's potable water supply. Additionally, this directly affects plant health as plants get their nutrients and water from local groundwater sources just beneath the surface.

### 1.7.2 Why is it important to conserve or restore New Zealand's natural community types?

Built environment professionals who are knowledgeable about New Zealand's natural communities can provide better urban development solutions for humans, plants, and animals. With the right knowledge and experience it is possible to protect, enhance, and/or recreate valuable natural habitat while simultaneously establishing a sense of place that will attract new homebuyers and sustain longtime residents. The same factors, e.g. climate and soil conditions, that determine what type of natural community a region of New Zealand would support are also valuable indicators for the types of buildings and landscaping that will succeed in that region as well. The social and urban communities in which humans dwell and the natural communities that plants and animals inhabit are interconnected in a complex yet complementary web of life.

In terms of conserving biodiversity, understanding the diverse natural community types in New Zealand is essential. In particular, particular animal and plant species only live in certain natural community types or ecosystems. When prioritised appropriately, sound development can minimise its negative impacts on natural communities and biodiversity as a whole.

Two major points must be considered when discussing New Zealand's natural communities. First, the current distribution of each community type is a mere fraction of what it was 100 years ago (particularly in lowlands). Second, without proper land use and management, nature can no longer maintain the remaining tracts of wildland. It is very challenging to distinguish and manage the most vulnerable natural communities as all are in danger. New Zealand, and each unique region and district within it, therefore has a special duty to protect its unique contribution to global biodiversity. There are three key steps we can take.

Step 1: The **most important conservation measure is to protect remnant primary habitat first** – for these are our benchmarks and seed sources for restoration of lost habitats. Also we cannot know the immense complexity of natural or historical ecosystems, let alone believe we can rebuild them from scratch. The expense would in any event be crippling – up to \$100,000 per hectare in real terms, just to get young plants of the dominant species established. *An ounce of protection is very much worth a pound of restoration!*

Step 2: But when the original is lost, then rebuilding habitats and natural character across the landscape is the last resort. This is **ecological restoration**. Being able to take part in the re-creation of lost heritage, watching it grow and regenerate and seeing the linkages reconnect is a rewarding experience. The positivity comes from revival of community, personal (wairua) and environmental spirit or life force (mauri) as well as from seeing the more tangible fruits of one's labour.

Step 3: Reduce impacts of built and farmed areas on surrounding natural areas. The important point is that natural communities are affected by nearby human-dominated landscapes (e.g. stormwater runoff, invasive exotics, human disturbance, etc.). For subdivisions, many design and management practices for yards and neighborhoods could be implemented to minimize these impacts and to help maintain healthy natural areas.

### 1.7.3 Types of natural communities

Below we highlight some major New Zealand natural community types. This is not an exhaustive list but gives some examples of the unique communities around New Zealand. Not all are directly associated with urban environments, but all are accessible within an hour's journey of our cities. Consequently, all are potentially impacted by human activities within and around urban and rural landscapes.

## Kauri forest and gumlands

### Kauri forest



*Kauri tree, Waipoua Forest, Northland.*

*Photo: Mark Hostetler*

- *Kauri forest* = evergreen, multi-tiered rainforest of kauri, podocarps, broadleaved trees, vines, shrubs, tree ferns, sedges, lilies and abundant flowering epiphytes
  - Confined to northern New Zealand; now much reduced; greatest biomass and most diverse forest type (originally approx. 10% kauri trees threatened by disease of the land area)
  - Threatened by browsing and predation by exotic mammals in forest
  - Threatened by Kauri dieback disease

### Gumlands



*Cape Reinga, Northland.*

*Photo: Colin Meurk*

- *Gumlands* = mānuka, heath, restiad and sedge shrubland derived from former kauri forest; very leached acid bog soils
  - Threatened by browsing and predation by exotic mammals in forest, by fire, encroachment by gorse, and new cycle of breaking in land by drainage and ripping for agriculture or forestry
  - Activities that disturb soil or hydrologic patterns make this community susceptible to invasion by exotic species
  - Gumlands are one of the more vulnerable communities to agricultural development
  - Closely related is Pakihi – a predominantly West Coast South Island version degraded from cupressoid podocarp-heath-restiad-tangle fern shrubland rather than from kauri forest.

## Podocarp rainforest

### Northern podocarp rainforest



*Mt Tongariro.*

- *Northern podocarp rainforest* = podocarp, evergreen, multi-tiered rainforest dominated by podocarps (rimu, miro, mataī, tanekaha), broadleaved evergreen trees (rātā, kāmahī, variously rewarewa, hīnau, maire, tawa, taraire), understory small trees, tree ferns, vines, flowering and fern epiphytes on leached to podzolic infertile soils
  - Originally throughout lowland North Island except in the kauri zone; much reduced in the downlands and plains; minor losses continuing
  - Species rich
  - Threatened by introduced mammal browsing and predation and to a minor degree by incremental farm development pressures

### Southern podocarp rainforest

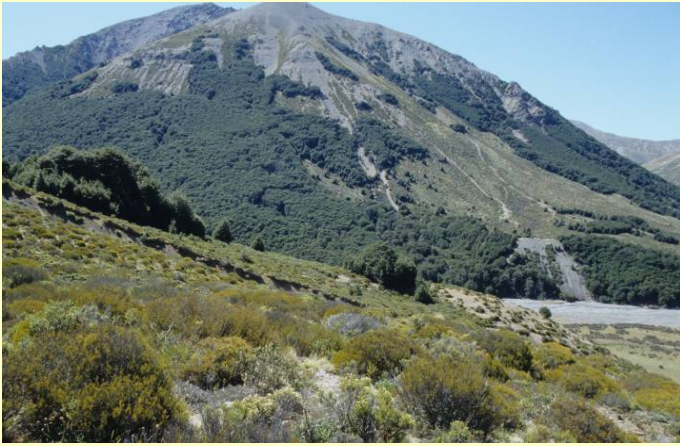


*Stewart Island.*

- *Southern podocarp rainforest* = podocarp, evergreen, multi-tiered rainforest dominated by podocarps (rimu, miro), broadleaved evergreen trees (rātā, kāmahī, pōkākā), understory small trees, tree ferns, vines, flowering and fern epiphytes and moss hummocks on podzolic infertile acid soils
  - Originally throughout lowland South Island west of the divide, in the south and south-east and dominant on Stewart Island; much reduced in the downlands and plains; small losses continuing for dairy conversion
  - Moderately rich in species; originally occupied by frugivorous and foliivorous birds
  - Threatened by introduced mammal browsing and predation and to a minor degree by incremental farm development pressures

## Beech forest

### Upland beech forest



*Upland beech forest with old fire-induced montane mixed scrub, Upper Hurunui, Mid Canterbury.*

- *Upland mountain/silver beech rainforest* = beech- dominated, evergreen, few-tiered rainforest to dry forest with subcanopy of broadleaved and small-leaved trees, ground and filmy ferns, moss hummocks and minor epiphytes on leached, low-fertility soils
  - Low to medium vascular plant diversity but large numbers of mosses, lichens and fungi
  - Originally insectivorous birds, parrots and honeyeaters feeding on honeydew
  - Plant composition varies along rainfall gradient
  - Threatened by browsing by introduced mammals has greatly reduced palatable understorey species such as broadleaf, shining karamū, five-finger and relatives, bush lily
  - Former threats from logging; potential for sustainable harvest of new forests provided old-growth forests are left intact

### Lowland beech forest



*Lowland red beech forest interior, Maruia, Lewis Pass.*

- *Lowland red/hard/black beech rainforest* = beech- dominated, evergreen, few-tiered rainforest with subcanopy of broadleaved and small-leaved trees, ground and filmy ferns, moss and minor epiphytes on medium fertility soils
  - Medium to low vascular plant diversity but large numbers of mosses, lichens and fungi
  - Originally parrots, honey-eating (feeding on honeydew) and insectivorous birds
  - Plant composition varies along rainfall gradient

## Mixed (disturbed or seral) hardwood forest

### Broadleaf slope forest or bush



*Broadleaf woodland with fern ground cover, Mt Somers, South Canterbury.*

- *Broadleaf slope forest* = evergreen, low statured, 2-tiered, rain- to dry-forest or woodland with broadleaf, mahoe, kamahi, olearia, tree fuchsia and/or rewarewa with understorey of browse-resistant small-leaved shrubs and fernland on often moderately fertile sites
  - Mostly derived or degraded from cut-over podocarp forest or coastal bush
  - Plant composition varies along rainfall gradient and often quite rich with seral and regenerating 'climax' forest species side by side.
  - Threats are browsing, conversion to exotic forestry, loss of regeneration, invasion by exotics

### Semi-deciduous seral woodland



*Kowhai (degraded) woodland in flower with willow and rushes at back, Motunau, North Canterbury hills.*

- *Kōwhai floodplain woodland* = semi-deciduous, 2-tiered young or seral woodland of kowhai or ribbonwood, lacebark, tree fuchsia or wineberry, sometimes with kanuka, on fertile floodplains, slips and other naturally disturbed sites
  - Canopy species composition varies along rainfall gradient
  - Threats are browsing, conversion to exotic forestry, loss of regeneration, invasion by exotics, then herbicide damage

### Cloud or Elfin Woods (dwarf rainforest)



*Montane beech – pink pine - cedar forest, Mt Ruapehu.*



*Subalpine beech elfin woods, Lewis Pass.*



*Subalpine oceanic dwarf forest, Stewart Island.*

- *Cloud or Elfin woods* = evergreen, small-leaved heathy and cupressoid conifer low forests near timberline or on exposed slopes in the south on leached, podzolised or peaty soils
  - Variousy dominated by mountain beech, NZ cedar, bog/pink pine, grass tree and tree daisies with dangling mosses and lichens
  - Threatened by deer and other ungulate browsing

## Floodplain forest

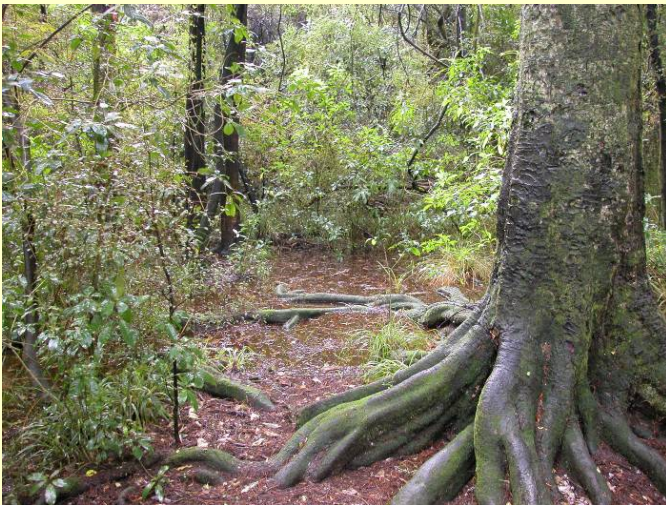
### Floodplain rainforest



*Floodplain rainforest, South Westland.*

- *Floodplain rainforest* = evergreen, multi-tiered rainforest dominated by emergent podocarps such as kahikatea, rimu and matai with co-dominant pokaka in south or pukatea in north, with rich understorey of lacey-leaved coprosmas, horopito, divaricating shrubs, tree ferns, vines, epiphytes and filmy ferns on fertile, alluvial, frequently flooded gley soils
  - Characteristic buttressed trunks and platform roots of dominant trees
  - Minor threats from browsing
  - Main threat from natural losses due to shifting river channels and flooding

### Floodplain forest



*Kahikatea-pokaka-hinau floodplain forest, Riccarton Bush, Christchurch floodplain forest.*

- *Floodplain forest* = evergreen, multi-tiered forest dominated by emergent podocarps such as kahikatea and matai with co-dominant pokaka in south or pukatea in north, with rich understorey of lacey-leaved coprosmas, horopito, divaricating shrubs and vines on fertile, alluvial, occasionally flooded gley soils in lower rainfall regions
  - Characteristic buttressed trunks and platform roots of dominant trees.
  - Plants that are rooted in the ground and not susceptible to leaf desiccation from drying winds are essentially the same as above.
  - Minor threats from browsing, from natural flooding and lowering of water tables through marginal drainage and stop banking

## Dry forest

### Dry kānuka woodland



*Dry kānuka woodland, with rice grass and chain fern, Rakaia Island, Canterbury.*

### Tōtara–mataī dry podocarp forest



*Woodbury, South Canterbury.*

- *Dry kānuka woodland* = small-leaved, 2-tiered seral or dry low forest of kanuka, kowhai or cabbage tree and divaricating shrubs (coprosma, korokio, porcupine shrub) sometimes with seedlings of broadleaved and podocarp trees, grass, fern and moss carpets – on fertile soils
  - Under-valued as nursery for future natural succession, succession paradoxically will eliminate this vegetation and if no new places for regeneration or gorse/broom invades, this once abundant natural community type could disappear, threats from clearance for pasture and forestry
- *Kōwhai savannah* = 2-tiered deral or dry woodland of kowhai, kanuka or cabbage tree on fertile floodplains
  - Highly threatened on the Canterbury Plains by farming intensification
  - Narrow window for regeneration of indigenous species between suppression by dense exotic grasses or stock grazing, under-valued as nursery for future natural succession
- *Tōtara–mataī podocarp forest* = evergreen, few-tiered, climax dry podocarp forest of totara, matai and mixed hardwoods and divaricating shrubs on moderately fertile, stable terraces and foothills
  - Threatened by clearances and browsing
  - Potential for sustainable indigenous forestry by planting new podocarp forests for high value, naturally durable timber

### Kōwhai savannah woodland



*Mcleans Island, Christchurch.*

## Scrub/shrubland (lowland)

### Matagouri scrub



*Grey scrub, Eyre Mountains, Southland.*

- *Matagouri Scrub* = part of the 'grey scrub' assemblage on fertile drift soils – river terraces, fans and stabilised scree – mainly in the South Island
  - Often rich in species with small-leaved coprosmas, korokio, porcupine shrub, NZ broom, NZ jasmine and bush lawyer vines – sometimes with emergent kowhai. Kakariki/parakeets feed on the seed.
  - Threats are clearance mechanically, by fire and increasingly by aerial herbicide.
  - Matagouri is a valuable species as it fixes nitrogen into the soil, is drought tolerant, hosts a fly that is parasitic on grass grub (natural biological control) and could be more widely used in open woodland under extensive pastoralism.
  - As NZ's only native spiny shrub and with a distinctive silhouette, is suitable for greater use in landscaping, especially to provide some deterrence to vandalism – along with bush lawyer

### Coastal scrub



*Wind-shorn scrub of mānuka and shrub daisies and small-leaved coprosmas, Kapiti Island.*

- *Coastal Scrub* = small-leaved divaricating and hedged shrubs of exposed coastal slopes
  - Diversity of shrub species many of which are berry producing - for small birds.
  - Important natural hedges for providing shelter from wind and salt spray.
  - Threats are from fire and exotic shrub invasion – especially gorse

## Scrub/shrubland (upland)

### Montane korokio scrub



*Korokio grey shrubland, Ryton Station, inland mid-Canterbury.*

- *Montane korokio scrub* = korokio-dominated, evergreen, pink-orange-berried shrubs – with yellow, insect-pollinated flowers, associated with matagouri and small-leaved coprosmas. Part of the 'grey scrub' complex on medium-fertility brown soils
  - Provide berries for birds and possibly lizards.
  - Mountainous and coastal areas throughout the country.
  - Threatened by clearances for pastoralism and forestry

### Podocarp-mixed subalpine scrub



*Subalpine scrub, Tongariro National Park.*

- *Podocarp-mixed subalpine scrub* = snow-tōtara-dominated, associated with coprosmas, dracophyllum, hebe, poa grasses on fresh volcanic scoria
  - Produce berries for frugivorous birds
  - Threats minor as most is in high country rocky or stony areas of little use for production.
  - Browsing by exotic mammals always a problem.

## Alpine and subalpine (tall tussock)

### Subantarctic tall snow tussock grassland



*Tall snow tussock grassland, Campbell Island.*

- *Subantarctic tall snow tussock grassland* = snow grass dominated, evergreen tussocks associated with many intertussock herbs, fine grasses, mats, cushions, filmy ferns and mosses and macrophyllous forbs on acid blanket peat soils
  - Originally snipe, pipits
  - Since exotic sheep, cattle and rats were removed in the 1970s–90s these palatable grasses have returned to pristine condition

### Low alpine tall snow tussock grassland



*Tall snow tussock grassland and mountain tarn, Mount Cook National Park.*

- *Low alpine tall snow tussock grassland* = broadleaved and midrib snowgrasses, evergreen associated with mountain daisies, buttercups, fine grasses leaf litter on loamy brown soils
  - Low to medium vascular plant diversity
  - Originally browsing birds like takahē, insectivorous birds
  - Browsing by introduced mammals outside of control zone has greatly reduced palatable grasses and forbs

## Short tussock grassland

### Montane fescue tussock grassland



*Mackenzie Basin, Central South Island.*

- *Montane short fescue tussock grassland* = hard or fescue tussock dominated, evergreen on low-fertility soils
  - Originated from burning of woody vegetation and then later tall-tussock grasslands which were replaced by less palatable short-tussock species
  - Heavy grazing prevents succession, but may provide degraded bare soil sites for some rare ephemeral plants
  - Medium vascular plant diversity with a number of mat daisies (scabweed), forbs, fine grasses and lichens
  - Weka, moa, and insectivorous birds and lizards would have roamed these basins
  - Major threats are competition from hawkweeds
  - The jury is still out on the best management – light extensive grazing or destocking and allowing succession back to woody vegetation
  - Both types of vegetation have their own associated values. A management gradient covering a range of management intensities may be the optimal approach
  - Many species are suitable and attractive in rock or scree gardens.

### Lowland silver tussock grassland

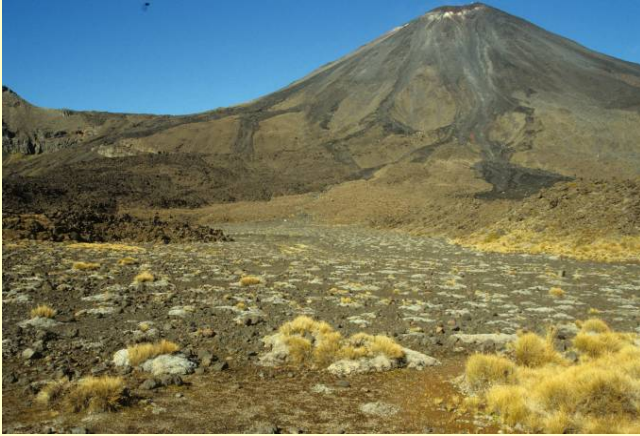


*Short, silver tussock grassland, Port Hills, Banks Peninsula.*

- *Lowland silver tussock grassland* = silver-tussock-dominated and now with exotic intertussock grass sward on medium-fertility soils
  - Low to medium vascular plant diversity but large numbers of mosses, lichens and fungi
  - Grazing by sheep preserves the predominant growth form; widely planted in large landscape swathes, but in the absence of sheep grazing or assiduous weeding, it only lasts a few years before being invaded and smothered by tall exotic grasses such as cocksfoot or prairie grass
  - Composition varies with rainfall gradient
  - Many native species from these grasslands are suitable and attractive in rock or scree gardens
  - Major threats and critical issues:
    - Overgrazing by cattle may rip out tussocks; otherwise main danger is being smothered by tall exotic grasses

## Turf/sward grassland

### Seral scabweed bunch grassland



*Sabweed and poa/danthonias bunch grass, Tongariro National Park.*

- *Seral scabweed bunch grassland* = scabweed, danthonia and poa dominated, on very recent scoria
  - Medium to low vascular plant diversity
  - Not many threats in the National Park

### Semi-arid subshrub turf grassland



*Stellaria gracilentia, danthonias grass and lichens, Alexandra, Central Otago.*

- *Semi-arid subshrub turf grassland* = poa, danthonia, wheat grass dominated on base-rich droughty rocky soils
  - Medium vascular plant diversity with grasses, scabweeds, lichens, native chickweeds, mat pohuehue, and ephemerals
  - Originally derived from burning and grazing of woodlands, shrublands and tussock lands; now home to many invertebrates, insectivorous birds, originally weka, and endemic lizards
  - Composition varies greatly according to position in catena and moisture gradient
  - Invasion by exotic weeds; but grazing is a two-edged sword – some diminutive native species owe their existence to extensive sheep and rabbit grazing, but many palatable species no long occur and respond to release from grazing – along with many exotic species like vipers bugloss and briar

## Herbfield and cushionfield

### Alpine cushionfield



*Vegetable sheep (Haastia pulvinaris), Nelson Lakes National Park.*

- *Alpine cushionfield* = classic vegetable sheep community above tree line in semi-stable coarse scree, associated with mountain daisies, bunch grasses, and other mountain herbs and subshrubs
  - Distinctive species but generally not suitable for use in temperate climate gardens because the air is too dry or too hot.
  - Threats are from hares, chamois and tahr browsing and rare alpine birds are increasingly vulnerable to mustellids and rats that appear to be extending their ranges upwards perhaps as a response to global warming
- *Maritime herbfield* = Macroforbs and tussock grasses characterise this coastal community
  - Threats are introduced browsing mammals on these highly palatable forbs
- *Alpine snowbank and herbfield* = short snowpatch grasses and mountain daisies with cushion plants, subshrubs and other forbs occur in endless variety in the mountains.
  - Threats are introduced browsing mammals – particularly hares, chamois and tahr and predators as above.
  - Coastal herbfields and banks harbour suitable species for rock and scree gardens, herb borders, planter boxes and green roofs with shallow soils

### Maritime herbfield



*Coastal carrot (Anisotome lyallii) and poa tussocks on southern coast, Stewart Island.*

### Alpine snowbank and herbfield



*Snow patch grass with mountain daisies, Waimakariri catchment, Canterbury.*

*All photos: Colin Meurk*

## Wetlands

### Sedge swamp



*Sedge reed flaxland, Chocolate Swamp,  
Stewart Island.*

- *Sedge swamp* = eutrophic swamp vegetation with mosaics of manuka, mikimiki, sedges, toetoe, Baumea and NZ flax.
  - Variants of this type of tall swamp vegetation is relatively common throughout NZ.
  - Important for swamp birds including fernbird and marsh crake
  - Much has been drained for production however, and there is an ongoing threat of this despite the RMA specifically itemising the importance of wetlands
- *Tussock sedge swamp* = eutrophic riparian and peatland vegetation with occasional manuka, mikimiki, sedges, toetoe and NZ flax.
  - Relatively common throughout NZ and much planted along rivers in recent years.
  - Threatened in other areas by removal, drainage and development
- Red tussock wetland = dominated by red tussock and sparse shrubs of manuka, mikimiki, olearia, tauhinu and grass tree on peat or gleyed soils in subalpine, montane and southern lowlands
  - The boggiest variants approach Pakihi or gumland vegetation on acid peats
  - Threats from drainage and intensification of agriculture in the south.
  - Many species from all these wetlands suitable for wet gardens, swales and riparian environments

### Red tussock wetland



*Subalpine red tussock grassland, Goulard Downs,  
Heaphy Track.*

### Tussock sedge swamp



*Riparian tussock sedge (pukio), Leeston,  
Canterbury*

*All photos: Colin Meurk*

## Coastal

### Coastal rainforest



*Nikau palm grove, Heaphy Track, North Westland.*

- *Coastal rainforest* = dominated by kohekohe, karaka, nikau, kawakawa, akeake (all in north), mahoe, mapau, ngaio, shrub daisies, karamu, mikimiki and mountain flax in the south.
  - A strong differentiation between northern and southern forests with many frost-tender species confined to the north or coastal hills
  - Threats from browsing mammals and infiltration by shrub weeds such as gorse

### Spinfex–pingao coastal sand dune



Wanganui.

- *Spinfex–pingao coastal sand dune* = simple community of drifting sand, occasionally with associated forbs and subshrubs like sand daphne, scleranthus, sand fescue, sand coprosma, sand sedge and sea spurge.
  - Threats to this community are grazing stock and browsing rabbits, competition from exotic marram grass, African iceplant, and tree lupin; and now sea level rise and a static fence

## Coastal

### Coastal pohutukawa



*Forest and Stipa grassland*

- *(Northern) Coastal pohutukawa forest* – apart from the classical pohutukawa there are a number of associated small trees in this northern community (see list in coastal rainforest). Puriri, mangaeo, karo, taupata and five-finger relatives are other associates.
  - Stipa tussocks, knobby clubrush, silver tussock and umbrella sedge are found on the banks below trees
  - Main threats are sea level rise browsing mammals

### Saltmarsh



*Saltmarsh of glasswort and sea barley Te Waihora  
Lake Ellesmere, Canterbury*

- *Saltmarsh* – estuarine, tidally flooded succulent vegetation of glasswort, Selliera, sea primrose and graminoids (Puccinellia, bristle sedge).
  - Mosaic with sea rush and oioi swards, important for wading birds that feed on crustaceans
  - Main threats from 'reclamation' and sea level rise
  - Far north, salt marshes dominated by mangroves

## Braided riverbed and herbfield

### Braided riverbed



*Upper Waimakariri River, Canterbury; fescue short tussock grassland and matagouri shrubland in foreground.*

- *Braided riverbed* = a classic feature of the eastern South Island of shifting shingle
  - Many species (e.g. scabweeds, fine grasses, mat pohuehue) suitable for rock and scree gardens, herb borders, planter boxes, and green roofs with shallow soils.
  - Important breeding habitat for specialised birds, especially the wrybill and stilts
  - Main threats = invading plants such as lupins, myricaria, gorse, and other exotic shrubs and grasses. These invasive plants also affect nesting birds by creating more cover for predators. Also hydro development is a threat.
  - Most of the native plants from these communities are useful for rock and scree gardens but require coarse (hyper-drained) substrates and frequent disturbance (gardening!)

### Herbfield



*Maori onion grazed herbfield, Takitimu Mountains, Southland – note unpalatable summer green lily.*

- *Herbfield* = summer green liliaceous herb (e.g., Maori onion) forming a quasi-stable association with low fertility exotic grasses in a native grazed meadow
  - Many associated native and exotic forbs and grasses – the key characteristic of the Maori onion is that it is unpalatable to stock.
  - Threats are trend to intensification – in fact this site is long since been converted to high producing, near monoculture pasture.
  - Some of associated forbs are suitable for garden environments

## 1.8 Financial strategies for conserving or restoring open space

The previous sections showed there are many reasons why one would choose to focus on improving biodiversity within an urban development or rural area. It aimed to introduce participants to the ecological concepts and reasons for focusing on biodiversity within expanding communities. This section introduces and discusses economic options for landowners and even developers to conserve and/or restore sections of their land to natural open space. Open space can be defined as 'any area of land or body of water that serves to preserve or to facilitate the preservation of any landscape of aesthetic, cultural, recreational, scenic, scientific, or social interest or value'.<sup>27</sup> Below, we highlight economic options for landowners and agencies that have funds or staff to help landowners to conserve or restore parcels of land.



*Travis Swamp, a conserved urban wetland in Christchurch. Photo: Mark Hostetler*

### 1.8.1 Conservation options for New Zealand landowners

Over 80% of New Zealanders live in urban areas and the most populous cities are located in the North Island. Urban growth brings humans closer to natural areas and can put stress on wildlife and natural communities. Yet these areas are also where most people view and enjoy wildlife. With a little planning, developments can be designed and managed to promote a healthy relationship between flora and fauna and people.

Many of New Zealand's natural habitats are in need of protection. Almost two-thirds of New Zealand's land environments are classified within one of the five threat categories: Acutely Threatened (<10% indigenous cover remaining), Chronically Threatened (10–20% indigenous cover remaining), At Risk (20–30% indigenous cover remaining), Critically Underprotected (>30% indigenous cover remaining, <10% legally

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<sup>27</sup> Excerpted from New Zealand's Queen Elizabeth the Second National Trust Act 1977

Protected) or Underprotected environments (>30% indigenous cover remaining, 10–20% legally protected)<sup>28</sup>. Most of the threatened habitats occur in coastal and lowland areas (which are highly suitable for rural and urban development). Most regions (based on regional council boundaries) have already been highly fragmented or converted to other uses, for example:

- Canterbury Region: dry, lowland areas (<10% of its original indigenous cover remaining)
- Hawke's Bay Region: dry, lowland areas near coast and rivers (<10% of its original indigenous cover remaining)
- Nelson Region: dry, lowland areas near coast and rivers (<10% of its original indigenous cover remaining)

Even New Zealand's agricultural lands are being converted into subdivisions. Increasing land values put pressure on landowners to pursue urban development. Agriculture is an important component of the New Zealand economy, and it contributes to the rural lifestyle of many New Zealand families. Not only do agricultural lands provide food, clothing, and building material, but these lands can provide for wildlife habitat, aquifer recharge, and flood protection.

Landowners across the country must make difficult decisions about how to use their land. For sites that are going to be subdivided or for large lots that are not going to be subdivided, portions of the land can be conserved or restored. These areas will not only serve as an amenity for community residents, but will also provide an economic gain for the developer or landowner. For those who wish to conserve or restore portions of their land in a natural or agricultural condition, **there are options**. The four major options are:

- Conservation covenants
- Direct sale
- A reserve contribution during subdivision
- Management funds and advice

Land conservation options have many benefits. Yet some people may not want to restrict their development rights or reduce their land's resale value. For example, conservation covenants may reduce the market value of the land. When making important land-use decisions, always consult with legal representation and financial advisors. Remember there are several land trusts. Contacting a variety of them may help landowners focus on the best options for their unique needs. For example, Banks Peninsula Conservation Trust has conservation options and guidance for landowners<sup>29</sup>.

**Disclaimer:** The information below is intended for general education. Individuals, businesses, and government entities that have legal or tax-related questions should consult their legal counsel or other specialists and references for assistance.

### Conservation covenants

Imagine that owning land is like retaining a variety of rights. The rights to subdivide the land, develop buildings, harvest crops, or establish a nature reserve are a few examples. A landowner can choose to donate or sell all of the rights or just a few of the rights.

Conservation covenants allow a landowner to voluntarily give away some rights to a conservation holder. This exchange can help maintain land in agricultural or natural uses. Easement holders can be government agencies or non-government conservation organisations. For more information about procedures relating to conservation covenants, visit:

[www.qe2.org.nz/](http://www.qe2.org.nz/)

<https://ccc.govt.nz/culture-and-community/community-funding/christchurch-biodiversity-fund>

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<sup>28</sup> Walker S, Price R, Rutledge D 2005. New Zealand's remaining indigenous cover: recent changes and biodiversity protection needs. Landcare Research Contract Report.

<sup>29</sup> Banks Peninsula Conservation Trust - <https://www.bpct.org.nz/>

A conservation covenant is a legally binding agreement between two or more parties to protect an area, such as a waterway, wetland, forest or hill country, either for a specified amount of time, or in perpetuity. Covenants can be used where conservation purposes may be achieved without acquiring ownership of the land. They are established by partners who agree on the values to be protected and the management regime to be implemented.

Conservation covenants provide opportunities to protect and restore natural ecosystems. Cities can help landowners to place covenants on their land<sup>30</sup>. Cities may partner with local land trusts or even enter into an agreement between the landowner, the city, and Department of Conservation. Conservation covenants have been used by the Department of Conservation over the years, but few local authorities have embraced covenanting as a tool.

Covenants are one such method of managing New Zealand's natural ecosystems under the Reserves Act (section 32, 1[a], [ii]). Under Section 77 a local authority or the Crown can establish a conservation covenant to protect habitats and ecosystems on private land. Covenants are a partnership agreement between a landowner or lessee of Crown land, and the Crown or a local authority.

Lessees of Crown land can also establish covenants. A lessee can request permission from the Minister of Conservation or Minister of Lands to put a conservation covenant on part of a leased property. Some local authorities may offer rates relief, which benefits the lessee. The benefit to the local authority and/or Department of Conservation is that land with ecological or landscape values can be protected and adverse land-use effects can be avoided. This situation might apply particularly in the case of land used for farming or forestry where there are areas of indigenous vegetation that may otherwise be impacted by topdressing, burning, drainage or grazing.

The length of time that the conservation covenant is on the land is negotiable and can be limited or forever. Typically, if a conservation covenant is placed on a piece of land, this will open avenues for landowners to obtain funds and advice to help manage the land.

There are a number of different types of covenants used in New Zealand. Several popular non-government organisations that administer covenants or help landowners to evaluate the potential of their land for a covenant are:

QEII Trust Covenants – [www.qe2.org.nz/](http://www.qe2.org.nz/)

NZ Landcare Trust (primarily an information broker and has lots of good educational resources for landowners – see <https://landcare.org.nz/>)

Various local organisations (e.g. Banks Peninsula Conservation Trust – <https://www.bpct.org.nz/>)

Government organisations that offer covenants or advise include:

Department of Conservation Covenants (see <https://www.nzpcn.org.nz/conservation/habitat-protection/legal-protection/doc-covenants/>)

Ngā Whenua Rahui Kawenata (which relate to Māori land or Crown land held under a crown lease by Māori, administered by the Department of Conservation – see <https://www.doc.govt.nz/get-involved/funding/nga-whenua-rahui/nga-whenua-rahui-fund/about-the-fund/>)

What are the benefits of conservation covenants? Landowners may see several benefits from pursuing a conservation covenant, such as:

- Conservation covenants appeal to property owners who are passionate about their land being conserved for present and future generations.
- Covenants bestow a high level of community recognition. They are a legal 'stamp' of its enduring worth.
- Landowners retain ownership.

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<sup>30</sup> This section excerpted from <https://ccc.govt.nz/environment/biodiversity>

- The landowner can determine access and the covenant's existence can be kept secret if the owner desires.
- Covenants are registered against the property title as a binding agreement on current and future owners of the property. This legal mechanism brings peace of mind and certainty for owners and purchasers and will see the values protected in perpetuity.
- In many cases, a council or land trust pays for the preparation of the covenant document, as well as a conservation plan, a survey plan (if required) and registration of the covenant with the District Land Registrar.
- With a conservation covenant, a conservation plan is adopted that provides a framework for the management of the heritage and natural values. It sets out principles and specific policies to guide future works and decisions for the property, including any change-in-use proposals.
- In some cases, land under covenant receives reduced property rates (check with your local authority).

### Direct sale

If the land has been recognised for its ecological or heritage benefit, several agencies may purchase the land directly from the landowner. The Department of Conservation's Nature Heritage Fund and Ngā Whenua Rahui have some money and educational resources to help landowners:

- Natural Heritage Fund, to purchase land – <https://www.doc.govt.nz/get-involved/funding/nature-heritage-fund/>
- Ngā Whenua Rahui Fund, to purchase land – <https://www.doc.govt.nz/get-involved/funding/nga-whenua-rahui/nga-whenua-rahui-fund/about-the-fund/>
- DOC has a small amount of funds to purchase conservation land – [www.doc.govt.nz](http://www.doc.govt.nz)

### A reserve contribution during subdivision

Sometimes local councils can acquire reserves during the process of subdividing the property. This can be a 'win-win' situation where the developer could gain additional allotments on a property and, in return, a potentially highly valued portion of the property (for biodiversity purposes) is conserved. It does not cost the council extra money, the developer gets to subdivide the land, and local residents can enjoy the green space (e.g. see Christchurch example – <https://ccc.govt.nz/consents-and-licences/development-contributions> and Rodney District Council's conservation lots strategy – <https://www.aucklandcouncil.govt.nz/plans-projects-policies-reports-bylaws/our-plans-strategies/unitary-plan/history-unitary-plan/docs335ruralsubdivision/Appendix-3.35.12.pdf>)

### Management funds for biodiversity

Most land that is designed to preserve biodiversity must be managed over the long term, and this can be a burden on landowners. Such management practices include trapping predators, planting native vegetation, removing invasive plants, and in extreme circumstances building a predator-proof fence. Several public and private organisations have funds explicitly meant to help landowners manage their land for biodiversity:

- NZ Landcare Trust – [www.landcare.org.nz/](http://www.landcare.org.nz/)
- Queen Elizabeth II National Trust – [www.qe2.org.nz/](http://www.qe2.org.nz/)
- Department of Conservation – [www.doc.govt.nz](http://www.doc.govt.nz)
- World Wildlife Fund – <https://wwf.org.nz/news/community-conservation/20242025-conservation-grants>
- Most regional and district councils have funds for assisting conservation management (e.g. Environment Canterbury)

## 1.9 How does local policies and regulations relate to growth management and biodiversity?

National and regional policies help guide local authorities when creating local growth management policies; some of the important national policies include the Resource Management Act of 1991<sup>31</sup> and the Local Government Act of 2002. The New Zealand Biodiversity Strategy Te Mana o te Taiao<sup>32</sup> is a national strategic framework on how to conserve and sustainably use and manage New Zealand's biodiversity. All of these national initiatives have bearings on how city and district councils regulate and plan for growth. However, it is very important to determine how design and management practices mentioned in this course fit in with local regulations and initiatives. In addition, local resources (such as contacts for local restoration advice or funding opportunities) can be quite helpful to developers and landowners that want to conserve or restore biodiversity on their land. An addendum may be included in this course that shows the interface with recommended design and management practices (from this manual) and current policy initiatives, including information about local resources and contacts. If no such addendum is included, contact local authorities and see how certain design and management practices (for biodiversity) relate to local standards and policies. One would not like to encounter procedural or policy barriers to a specific practice or design; in fact, one may discover that local conditions strongly encourage certain practices and a developer that implements them will have an easier time through the resource consent process.

## 1.10 Examples of sustainable development programmes and policies from the USA

In this section are policies and sustainable development strategies that have been attempted in the USA. Some of these strategies are relevant to conserving or restoring open space and others suggest different ways to encourage smart growth, such as helping where growth occurs within a community. The purpose here is to give information about US strategies that may be of interest and perhaps adopted and refined for New Zealand. We offer the below examples and discussion as a way to foster the adoption of new or the support of current biodiversity programmes and policies. There are a number of new and alternative programmes and policies that local US governments have used to increase conservation of open space, natural resources, and biodiversity. Typically this involves some form of growth control and smart growth planning. Many of the below examples relate to open space conservation, but we also included examples that relate to buildings and landscaping as they (indirectly) impact biodiversity. Some of the more common growth management measures include:

- *Smart growth programmes:* Multiple approaches exist. Initiatives such as urban growth boundaries are part of more efficient and compact urban development patterns. These can help protect sensitive natural areas and preserve valuable open space. These objectives are achieved in various growth strategies in New Zealand, such as those for Greater Auckland and Christchurch.
- *Alternative zoning ordinances:* A variety of alternative zoning ordinances benefit wildlife habitat conservation:
  - *Overlay zones:* Underlying zoning standards can be supplemented with an overlay zone. These overlays may include additional requirements designed to preserve specific natural features in a critical natural community. In New Zealand the Waitakere City Council has a twin-layer approach to its District Plan, i.e. there are two types of maps: 'natural area' maps and 'human environment' maps.
  - *Cluster development:* An applicable zoning ordinance may allow or require cluster development. This type of development preserves existing natural areas on a property by limiting development to a specific portion of the property. Sometimes allowable development densities may be increased to encourage clustering.

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<sup>31</sup> For a good review of the RMA and LGA - see Ministry for the Environment's 'Understanding the RMA' – <https://environment.govt.nz/publications/understanding-the-rma-and-how-to-get-involved/>

<sup>32</sup> To learn more – <https://www.doc.govt.nz/nature/biodiversity/te-mana-o-te-taiao-aotearoa-new-zealand-biodiversity-strategy-2020/aotearoa-new-zealand-biodiversity-strategy/>

- *Incentive zones*: Larger-scale development can be directed into designated growth areas through incentive zones that offer developers significant waivers of zoning requirements.
- *Impact fees*: Impact fees (often termed 'development contributions' in New Zealand) are a mechanism for making owners of new developments responsible for a share of the new public service infrastructure required for the property. This reduces the financial impact on current residents by transferring a portion to the owners of the new development. Impact fees can also be assessed to raise funds for community recreation and open space needs as well as infrastructure.
- *Community Development Districts (CDDs)*: CDDs are a special-purpose unit of local government that can be used to assist the delivery of urban community development services such as landscaping, parks, infrastructure, and the preservation and management of natural areas. CDDs are governed by an elected board of supervisors and established pursuant to Chapter 190 of the Florida Statutes. For more information and a formal definition of CDDs please visit the Florida Statutes website at [www.flsenate.gov/statutes/](http://www.flsenate.gov/statutes/) and click through to Title XIII: Chapter 190 – Community Development Districts.

### Box 2 Case study: Lakeshore Park (Harmony, FL)

The town of Harmony, near St Cloud, Florida, is creating a vast open space network throughout its community. Possibly the most innovative feature of Harmony's open space network will be Lakeshore Park along Buck Lake. Instead of designing lakefront home lots, Harmony chose to create a buffer of wooded wetlands along with a public park. Why would Harmony choose to forgo the potential profits from this incredibly valuable lakefront property you might ask?

Harmony is hoping to show that preservation of wildlife habitat and corporate profits are mutually compatible. In conjunction with the Florida Statutes, the Harmony Community Development District (CDD), a local unit of special-purpose government, was established to provide and maintain many community infrastructure projects such as parks, roads, and right-of-ways. CDDs are not uncommon in Florida as over 100 such districts have been established since this statute's inception in 1980. **This may be something local councils in New Zealand might consider as an option to conserve open space.** Like other CDDs, Harmony's developer reaps the benefits of the additional up-front money received by the issuance of capital infrastructure bonds while the residents of Harmony benefit by having lower initial housing costs and a wider array of infrastructure amenities. Ultimately, the residents of Harmony will repay these bonds through special bond assessments to the CDD and pay it through homeowner association fees.



Source: Harmony, FL

However, Harmony believes it has innovatively addressed these potential CDD limitations by using some of the capital infrastructure bonds to permanently preserve the 500-acre Buck Lake and a buffer of wooded wetlands along its shores. The US\$4.7 million present-value portion of the CDD bond was allocated toward the purchase of the land from the developer and will be amortised over a 30-year period for 2000 residential units. The average annual cost for each homeowner for the preservation of this land is approximately US\$200 per year (paid through homeowner association fees).



Source: Harmony, FL

By buffering the lake from upland pollution, maintaining the wildlife habitat, and creating Lakeshore Park as a shared community amenity, Buck Lake should prove to retain considerably more value over time. Essentially, Harmony has distributed the value of these 27 acres of prime real estate to all 2000 residential units, instead of a very small group of lakefront homeowners. The shared amenities offered by Buck Lake's wooded wetlands and the planned Lakeshore Park are expected to increase the value of each residential lot, thus making habitat preservation worthwhile for the homeowners, the developers, and the wildlife.

- *Transferable development rights (TDRs)*: TDR programmes direct development away from sensitive natural communities (sending areas) and into areas where growth is more desirable and more sustainable (receiving areas). This system works through free-market enterprise. It compensates landowners who voluntarily forfeit the development rights on their property. Essentially sending-zone landowners receive development credits that can be used within other areas of the property or sold to developers or land speculators outside of the property. When a landowner 'transfers' these development rights to another portion of their property or to another entity, they must place a permanent conservation easement on the sending portion of their land. The receiving-zone landowners can then use their purchased development credits to develop that

portion of their property at higher densities than would otherwise be allowed. A good example of the benefits of TDRs is detailed below:

- Montgomery County, Maryland, near fast-growing Washington, DC, established its TDR programme in 1980. By the end of fiscal year 1997, the TDR programme had protected 39 180 acres (out of a total sending area of 89 000 acres) under protective easement. Prior to 1980, the county lost an average of 3500 acres of farmland per year to development. (Source: <https://montgomeryplanning.org/planning/agricultural-reserve/transferable-development-rights/>).
- Lake County, Florida. Development rights within the Wekiva River basin can be transferred to other portions of the County in an effort to protect natural areas of the Wekiva River.
- *Purchase of development rights (PDRs)*: Local, State, or Federal governments or non-profit conservation organisations use PDR programmes to purchase development rights from voluntary landowners who desire wildlife habitat and natural resource conservation, while still retaining ownership of the property. Typically, development activities are permanently restricted for current and future owners of the property.
- *Priority funding areas (PFAs)* – State support for growth-related projects can be limited to locally designated growth areas through PFAs. These priority funding areas may affect public services such as sewer and water systems.
- *Mitigation Banks*: Developers sometimes encounter situations where the impact of urbanisation on natural communities such as wetlands might be unavoidable. In these situations ‘off-site’ mitigation banks can be used to consolidate natural habitat into a single, viable area instead of multiple small, scattered, and potentially unmanageable sites. However, mitigation banking is a very complex issue and there might be better alternatives on your development site. To learn more about wetland mitigation in the USA, see US National Mitigation Banking Association – <https://environmentalbanking.org/>.
- *Incentive-based Policies*: In Florida and many parts of the country, because conventional construction development has been going on for such a long time, it usually takes some encouragement or regulation from policymakers to ‘jumpstart’ the creation of green communities and conserving or restoring open space. In Florida, several counties have implemented voluntary, incentive-based policies to encourage the construction of energy-efficient homes. These ‘carrots’ provide builders with economic incentives, such as reduced costs of permits and fast-tracking permits. In one example, Gainesville, Florida implemented a policy that gave builders a US\$600 reduction on their building permit when they built energy-efficient houses (see <http://edis.ifas.ufl.edu/UW252>).

Mark Hostetler and his graduate student (Marisa Romero) investigated the impact of incentive-based policies in Florida and elsewhere. What was the uptake of these policy initiatives by private developers and builders? They found the most successful policies had these three ingredients:

1. Government officials and staff explicitly involved stakeholders to help craft the incentive-based policies. Public workshops were held that involved built environment professionals and the public. These workshops were informative and helped identify the barriers to constructing energy-efficient houses. Information from these meetings helped craft incentives that truly were incentives to built environment professionals. In some instances where the policy did not have a large uptake, incentives were crafted by government officials without input from the public. These incentives were not sufficient to attract developers.
2. A well-crafted education campaign was promoted within the community and was successful in educating built environment professionals about the new policies. In most failed instances, where the uptake was quite low, the common complaint was that builders and developers just did not know about the policies. Most of the effort went into crafting the policy, but no resources were used to educate the public about the new policies. Thus, even a good policy just sat on the books for years.
3. Successful policies had to have this ingredient – government capacity. Essentially, if a new building practice was to be encouraged, then all of the departments within the government had to

understand this new practice and accept it. Often planners and engineers would support and develop policies that would promote new types of building practices; however, often the regulatory officials were not aware of these new building practices and did not understand them. Often without support from regulators, builders that tried to implement new building practices were delayed by outdated codes and regulations. The end result was a delay in the permitting of the construction. This frustrated builders and cost them more money (in terms of delays) than if they had built a conventional home. Thus, the governing bodies must have their 'ducks in a row' before implementing a new policy.

Overall, the following steps should increase the uptake of incentive-based policies. First, one should hold a series of public forums to involve and educate the built environment community. These should be well-advertised functions and the goals of these forums are not only to educate the public about energy-efficient building practices, but also to identify barriers perceived by the built environment community and incentives that they would like to see. Second, after placing the policies on the books, government should implement a well-funded advertising campaign in print, radio, and local television. In fact, a city should try out the policy (first) on new government buildings; this will help work out the 'kinks' in the system and promote model building for other contractors to see. Third, a culture of sustainability should be apparent throughout various government agencies. In particular, separate departments need to identify codes and regulations that may serve as barriers to a novel building practice. Often, these conflicts are found within any municipality, and internal workshops should be held to remove potential barriers. To help New Zealand municipalities implement some incentive-based policies, a series of reports have been produced that evaluated the impact of various ordinances, and each report contains the actual language of the incentive-based policies (tried in the US) that promote various 'green' development practices. The reports can be found at: <http://edis.ifas.ufl.edu/UW254>; [edis.ifas.ufl.edu/UW254](http://edis.ifas.ufl.edu/UW254); <http://edis.ifas.ufl.edu/UW252>.

- *US Green Certification Organisations:* In recent years, several green certification programmes have been established to give recommendations of sustainability practices to design/build professionals and also some merit (in terms of a certificate) for those organisations that reach some level of sustainability. In some situations, the certification process has raised the profile of conserving and restoring natural areas within the subdivision. There is the US Green Building Coalition ([www.usgbc.org/](http://www.usgbc.org/)) that has established the LEED programme (Leadership in Energy and Environmental Design). Here the focus is on buildings and they are certified based on a point-based system: a minimum must be attained to receive certification but more-sustainable buildings can attain Silver, Gold, and Platinum certifications. Typically, LEED points are based on a wide variety of criteria that address some sort of energy and water conservation and other sustainable practices such as habitat protection and indoor environmental quality. Audubon International ([www.auduboninternational.org](http://www.auduboninternational.org)), another certification organisation, got its start in promoting and certifying green golf courses. It has since branched out and started certifying master planned communities. This certification programme also gives merit at different levels but the focus is more on the horizontal structure, in other words, the landscaping and site layout (e.g. where homes and roads are placed and conservation of open spaces). Other state and even local certification programmes exist (e.g. Florida Green Building Coalition – <https://floridagreenbuilding.org/>), but the commonality among all programmes is that each has some criteria that design/build professionals need to meet in order to reach some level of certification.

Although these programmes are noteworthy, certification programmes have a number of pitfalls and shortcomings. Both environmentalists and developers see the need for certification programmes. Environmentalists hope such programmes will help set standards of building practices that will have a measurable positive impact on our environment. Most developers want the same thing (being good corporate citizens) but they also want to achieve some level of greenness in order to market their communities to homebuyers. Usually, many options exist to reach certain degrees of sustainability. Opponents suggest that certifications tend to be prescriptive and not related to what is the best solution for a particular site; through a menu of options, one can choose different ways to get a certification. Proponents state that something is better than nothing and we need to take 'baby steps' and not make the certification unattainable by a majority of people. Further, many of these certification organisations have brought sustainability thinking to the forefront and developers are beginning to explore new ways to subdivide.

## Part Two: How to do it: design, construction and post-construction



*Seaside neighbourhoods in Nelson, New Zealand Photo: Mark Hostetler*

### 2.1 Objectives

- ✓ Prioritise plan and design elements to set the framework for improving biodiversity across the whole site with attention to surrounding landscapes (Phase I: Design)
- ✓ Understand and implement construction practices that will ensure realisation of the plans and design outlined in Phase I (Phase II: Construction)
- ✓ Understand and implement management practices that will help achieve the long-term goal of improving biodiversity across a site (Phase III: Post-construction)

### 2.2 Introduction

Part 1 showed there are many reasons to improve biodiversity and it aimed to introduce participants to the ecological concepts underpinning biodiversity conservation within expanding urban environments. We highlighted economic options for landowners and New Zealand agencies that can help to conserve or restore land.

We do leave an important part of the discussion out of this course, and this is site selection at the broader scale<sup>33</sup>. As communities grow, where should urban areas, roads, reserves, and agriculture go? Can the spatial geometry of different land uses be optimised to benefit regional biodiversity? This broader-scale decision is very important, but regional-wide planning strategies are not discussed here. For a New Zealand ecological context of regional planning, see van Roon and Knight (2004)<sup>34</sup>.

Part 2 of this course focuses on what to do after a site has been selected for development. This part of the manual is devoted to describing ways to conserve and improve biodiversity within urban and rural environments and to minimise impacts on surrounding areas. It follows the **three phases of development**:

- Design
- Construction
- Post-construction

The design phase is typically where, among other aspects, lot size and open space is designated, and roads are distributed throughout the site. Goals for the project are discussed and prioritised. In this phase, for a conservation subdivision, homes could be clustered in a defined space and the remaining area designated as (natural) open space. Basically, everything is laid out on paper and it is more about where things go and the juxtaposition of vertical (i.e. buildings) and horizontal structures (i.e. roads, lots, conserved areas, and shared spaces).

Next, during construction, a whole host of architects, contractors, and subcontractors take whatever is on paper and implement this on the ground, constructing homes, streets, waste treatment systems, and landscaped areas (i.e. sections and parks).

Post-construction is the last phase, where buyers purchase the homes, move into the community, and manage their own homes and sections, neighbourhoods, and common areas.

All developers must consider these three development phases when creating a residential neighbourhood. It should be noted that the interaction of site design, construction, and post-construction is quite dynamic and plans could change as a project progresses. For example, the boundaries of conserved areas may change due to information learned as homes and roads are constructed. Although the focus here is on urban subdivisions, the three phases also relate to rural landowners who are trying to improve biodiversity on their land. When rural landowners are setting aside and/or restoring parcels of land, they have to decide where to place the boundaries of the restoration or conservation areas (design); they have to know which trees to plant and how to install them in order to promote long-term survival (construction); and they have to understand which management practices to implement to ensure the long-term viability of the site (post-construction). In addition, many of the design principles and management practices mentioned in Part 2 will help existing homeowners to improve biodiversity on their properties, basically retrofitting their residential community. Thus, the information contained in Part 2 is relevant to rural landowners, existing neighbourhoods, and developers.

From our experiences with communities planning to conserve or restore biodiversity, most of the emphasis is placed on the design phase and less on the construction and post-construction phases. However, the construction and post-construction phases are just as important as they impact biodiversity over the long term. During the construction phase, without trained or fully engaged contractors or landscapers, many things can happen that could impact the viability of nearby wildlife habitat. For example, even if the most important large trees are preserved across the subdivision and built areas are designed around them, the placement of topsoil and routes used by heavy construction vehicles are critical to the survival of these trees. It's not enough just to place a fence or flagging around the trunk of the tree. The roots underneath the drip line (the outer edge of the leafy canopy) should be protected by a sturdy fence. If heavy vehicles continually run over the root zone of a tree or

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<sup>33</sup> van Roon M, van Roon H 2009. Low Impact Urban Design and Development: the big picture. [https://www.landcareresearch.co.nz/assets/researchpubs/Science\\_Rep\\_LIUDD\\_optimised.pdf](https://www.landcareresearch.co.nz/assets/researchpubs/Science_Rep_LIUDD_optimised.pdf)

<sup>34</sup> van Roon M, Knight S 2004. Ecological context of development. New Zealand perspectives. Oxford University Press, Melbourne, Australia.

topsoil is placed right up to the tree trunk, the roots may not be able to acquire nutrients, water, and oxygen and the tree may die. Once the homes are built and people move into a neighbourhood, additional problems can arise if residents are not fully engaged – imagine homeowners moving in and planting invasive weeds on each of their sections. We now discuss biodiversity in detail pertaining to all **three phases of development: design, construction, and post-construction.**

## 2.3 Phase I: Design

In order to benefit New Zealand's plants and animals, the first step is to have an optimal site plan where preserved and/or restored natural habitat is maximised and intermingled with the built environment. **The focus here is on the big picture – where does one place the building sections, conserved natural areas, roads, etc. The details for design and construction in each of these areas are explained in Phase II: Construction.**



*Concept plan for Aidenfield Community, Christchurch. Design: Frazer Baggaley, 2005*

Many of the principles mentioned in this section come from general ecological principles and theories. However, some of this section is adapted from Best development practices: Doing the right thing and making money at the same time by Reid Ewing; the Green Development Designation standard reference guide (Version 1.0) by the Florida Green Building Coalition, Inc.; and from How to put nature into our neighbourhoods – application of Low Impact Urban Design and Development (LIUDD) principles, with a biodiversity focus, for New Zealand developers and homeowners (Ignatieva et al. 2008 – Lincoln University, Landscape Architecture Group, Environment, Society and Design Division; Landcare Research; School of Architecture and Planning, Auckland University; New Zealand Research Centre for Urban Ecology, Christchurch).

Key steps in designing developments and land for biodiversity are:

1. Work with key people to prepare your design
2. Analyse your site's significant natural resources
3. Concentrate development on previously disturbed sites
4. Provide animals with food, water, cover, and space
5. Conserve natural areas according to ecological principles
6. Conserve high-quality and rare natural communities
7. Create a network of open space and nature parks
8. Create a green transportation system
9. Consider nearby habitat and people
10. Conserve wetlands
11. Conserve drained margins around wetlands and natural water bodies
12. Enhance Māori values in urban and rural environments

### 2.3.1 Work with key people to prepare your design

Designing for biodiversity takes a collaborative effort. As mentioned previously, all parties in the development process – planners, architects (design phase), civil engineers and contractors (construction phase) – must understand why and how natural habitat is being conserved or restored. Most importantly, the plan must include the homeowners (post-construction phase), as they will be ‘managing’ the property long after it is built. During initial discussions, input from a variety of players is needed in order to create a good design that meets the needs of people within a community and satisfies the goal of improving biodiversity. In particular, become familiar with local city and regional councils and iwi that have regulations and/or strategic policies regarding biodiversity. How does your land fit in with local community needs and aspirations? What ‘win-win’ options are there to make your development profitable and also improve biodiversity?

Once you have established your goals for your site, you need to hire trained and motivated built environment professionals to put your ideas and ambitions on paper. It is critical to involve the right people because every site has a range of options and your goals may not be fully realised if people that are putting it on paper are not fully engaged and motivated to conserve biodiversity.

### 2.3.2 Analyse your site’s significant natural resources

The best development designs begin with a thorough inventory of the existing site. A variety of economic, social, and natural benefits are available to built environment professionals who incorporate the existing features of a site into their development plans.

Concentrate on conserving the most significant natural resources on your development property. This effort requires the coordination of experts in a variety of disciplines. Conserving multiple resources will benefit multiple wildlife species. The following surveys are useful when planning to conserve biodiversity:

- Vegetation and tree survey
- Topographical survey
- Wildlife survey
- Wetland survey
- Soil survey

These surveys will help you prioritise the most valuable areas for conservation or restoration on a parcel of land. Some areas of the property are more ‘pristine’ and not as degraded as other areas. Degraded areas typically contain exotic plants and may have had a recent human use (e.g. cultivated pasture land) that contributed to it being of less value ecologically. Also, the size of the area and surrounding land use should be factored in when ranking an area (see section 2.3.6: Preserve natural areas according to established ecological principles).

In terms of animals, does your land support high species diversity and/or contain listed species? Is the location and habitat quality suitable for supporting endangered and threatened species of wildlife that occur in the area? A good wildlife species inventory (along with vegetation inventories) will help provide information about where to locate conserved areas or areas targeted for restoration of wildlife habitat. In particular, be aware of surrounding land as areas within your site could augment nearby areas to produce effectively large patches of wildlife habitat. Similar types of survey should also apply to archaeological and cultural factors.

### 2.3.3 Focus development activities on previously disturbed sites

There are many types of previous site disturbance. They range from managed forestry, grazing, and agricultural uses to the more permanent and disruptive urban uses. It is best to redevelop areas already altered by buildings and roads or other human land uses. Advantages include pre-existing municipal services, established transportation networks, and no net increase in fragmented wildlife habitat or impervious surfaces.

Again, an ounce of protection is worth a pound of restoration! Protecting rapidly diminishing primary habitats has to be a priority. These are the benchmarks, reference points and seed sources for

restoration. Patches of original native vegetation (no matter how degraded) are precious heritage and are essentially irreplaceable. Contemporary patches may be composed of remnant or restored native trees, shrubs, ferns and/or grasses, and also exotic woods – which all can have some value as habitat or nurseries. Avoid removing such habitat at all cost. We don't have much left in lowland areas.

Old, historic or 'noble'<sup>35</sup> trees, that are indigenous, or are beneficial 'safe' exotics, should be protected *where they are found*. Old water races and stream banks that support swamp kiokio (*Blechnum minus*), sedges and rushes should be carefully protected and managed back to health where they have become weed-infested or otherwise degraded. These are often all that remains of the once abundant wetland vegetation of the lowland areas (e.g. Canterbury Plains) and it is always best to build more habitat around remnants (even an individual bush or fern) than to clean everything out and start from scratch.

Be careful about 'reclaiming' or converting marshy paddocks into ponds – because *wetland*, with all its rare dwarf plants, is quite different from relatively sterile or eutrophic *water* (full of mallard ducks) – now a common commodity because of such conversions. A botanist may be needed to check the minutiae of wet paddocks, although if it has been cultivated in the past it is unlikely to retain very much of interest.

By protecting vegetation *within your site*, both topsoil and subsoils are also protected. The properties of the upper subsoil (0.2 to 1 m depth) can be critical in supporting ecosystems, and may be altered dramatically when subjected to earthworks, particularly in fine-textured soils. In particular, the local soil on a site is full of unique soil biota, including thousands of unique and beneficial bacteria and fungi. It also contains (if it has not previously been disturbed) an excellent source of local seeds and soil fauna. Retaining such healthy soils will decrease the care and maintenance required for any new vegetation planted. It sometimes takes thousands of years to form healthy soils and even removing topsoil, storing it, and returning it to the original location does not really work. It is such a disruptive process that it destroys soil structure and it will take years for the soil to return to its original state. On disturbed sites that need soil or 'fill', care should be taken to only use soil from other locations within a construction site. Conserving local topsoil and reducing compaction of soil on site will eventually benefit any (future) planted vegetation.

When your development site does not include pre-existing urban infrastructure, it is better to build on abandoned pastoral or agricultural lands than on existing natural communities. Areas less affected by previous human activities should also be considered less desirable for new development.

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<sup>35</sup> 'Noble tree' is a term used in Europe to denote the grand, long-lived and characteristic trees of the continent – oaks, elms, lindens. In a New Zealand context we are talking about podocarps (tōtara, rimu mataī), elaeocarps (hīnau, pōkākā), lemonwood, ribbonwood and lacebark; kauri, pōhutukawa, rewarewa, puriri, taraire, and tītoki (in the north); and kōwhai, kānuka and cabbage trees (in drylands)

### Box 3 Case study: Building in agricultural areas (Harmony, FL)

The town of Harmony is located just outside St Cloud along Highway 192 in Osceola County, Florida. This new 11 000-acre mixed-use development is built on the former Triple E Ranch. Since the design phase, reducing the environmental impact of this development on the surrounding natural communities has been a priority. In addition to building all the homes to meet Energy Star® standards, the vast majority of buildings and transportation infrastructure were planned on the former cattle pastures. This allowed Harmony to preserve nearly all of the wooded wetlands along with two 500-acre lakes. Conserving these natural areas has lowered development costs by reducing the amount of land clearing required while simultaneously increasing property values by creating a network of shared green space for the community. As the pastureland was adjacent to the highway, focusing the development in this area has also increased exposure for this new community.

Yet Harmony did not stop there. By installing two pieces of artwork that symbolise the agricultural history of the Triple E Ranch, Harmony will foster a strong sense of place among its residents. The Florida natives sculpture by Kia Ricchi reused a former Triple E Ranch roller packer, designed for pressing hayseed into the soil, to depict over 30 different species of wildlife native to this region of Florida. From a barn by Fred Garbotz reused steel beams from the former hay-drying barn at the ranch to represent the evolution from agricultural to residential use of the land. Another unique way Harmony took advantage of previously disturbed sites was planning for the pipeline right-of-way to become an internal connector for future development phases. This right-of-way will become a corridor connecting residents to distant natural areas and future neighbourhoods. Designing this low-intensity thoroughfare will give residents the freedom to walk, bike, or drive golf carts around their community thus avoiding the high-intensity access roads designed for cars.



*From a barn sculpture Source: Harmony, FL*

#### 2.3.4 Provide animals with food, water, cover, and space

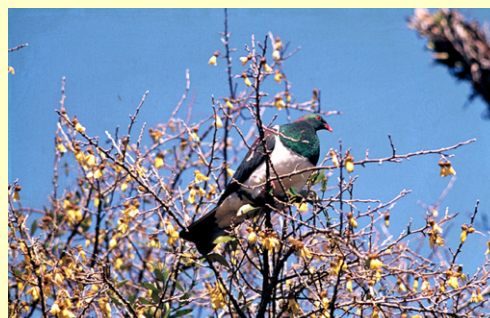
*All animals need food, water, cover, and space.* As mentioned previously, these four items make up 'functional' wildlife habitat. Based on vegetation and wildlife surveys, you may want to concentrate on conserving or restoring habitat for particular species that are found on or near the site. Identifying areas to conserve or restore is important, but one should also consider using native plants in built areas such as sections and stormwater retention ponds (see section 2.4) and implementing long-term management practices such as invasive exotic removal (see section 2.5).

*Different animal species prefer different types of habitat:* Some species like forested and wetland areas, others prefer open space such as meadows, and some prefer a combination of open space and forest areas. Many generalist species (e.g. pūkeko) will eat a variety of food items and live in a variety of habitats. Thus, any design and management plan for a property must consider the target species. Any plan will benefit some species and not others. For example, a fragmented landscape with high quality patches is fine for some bird species (e.g. grey warbler) throughout the year and can serve as dispersal sites where birds can acquire temporary food and shelter. However, for certain birds during the summer, a fragmented landscape in combination with urban activities (e.g. noise pollution, lights, traffic, pets) may not be appropriate for breeding (e.g. kiwi, takahē, kākā, fernbird), as they need large, undisturbed patches of habitat to raise offspring successfully. One would concentrate on perhaps providing vegetation buffers between the built areas and sensitive wildlife habitat. However, many native birds that can utilise urban areas when habitat is provided include pūkeko, silvereeye, tūī, bellbird, paradise shelduck, kererū, Australasian harrier hawk, and fantail.

### Box 4 Case example: provide habitat for tūi and kererū<sup>36</sup>



**Figure 6** Tūi. Photo: Landcare Research



**Figure 7** Kererū. Photo: Landcare Research

The tūi (Figure 6) and kererū (Figure 7) are special birds that can live in urban environments if the right designs and management practices are implemented. Below, we discuss some of the options a developer has in developing a neighbourhood that is attractive to these birds.

#### Providing habitat

Developers can provide foraging and nesting habitat by planting and conserving vegetation that these birds like. The presence of seasonally abundant food in both rural and urban areas is important for the long-term survival of tūi and kererū. These birds can fly long distances to feed on their preferred foods. Roger, a satellite-tagged kererū, made an extraordinary 57-km journey from Otatara to Stewart Island/Rakiura. However, the journey didn't end there, after three days of rest and food, Roger left the island and was next found in the Hokonui Hills several days later.

Preferred native foods for kererū are miro (fruit), kōwhai (leaves and flowers), makomako/wineberry (fruit), horopito (fruit), cabbage tree (fruit), and mataī (fruit). Typical kererū habitat includes a dense mix of podocarps and broadleaved trees with a well-developed shrub layer. Preferred native foods for tūi are kōtukutuku/tree fuchsia (nectar), kōwhai (nectar), harakeke/flax (nectar), and kahikatea/white pine (fruit). Typical tūi habitat includes a dense mix of podocarps, beech, and other large trees such as hīnau (*Elaeocarpus dentatus*) and pukatea (*Laurelia novae-zelandiae*), with an understorey composed of *Coprosma* with taller emergent plants.

#### Predator control

Rats, possums and mustelids (stoats, ferrets and weasels) have proven to be the primary predators of tūi and kererū. These predators are known to eat native birds' eggs and chicks and possums compete with adult birds for food. Domestic and wild cats also pose a danger. Reducing predators will provide kererū and tūi with a greater chance of survival.

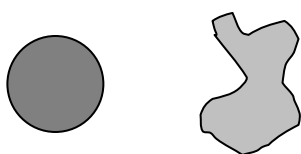
Developers can implement a control programme during the construction phase that includes traps, baiting, and preventative measures around trees where these birds nest (see [www.doc.govt.nz/](http://www.doc.govt.nz/) for trapping methods). Homeowners can install cat bibs on their outdoor cats to help prevent them from hunting, or keep cats indoors. Alternative predator control techniques that developers can place on trees include placing a wide metal band (similar to those around power poles) around tree trunks where birds nest. A metal band prevents predators such as rats, possums and cats from climbing the tree. Nearby trees should also be banded as predators can move between interconnecting trees.

<sup>36</sup> Information in this section was excerpted from a pamphlet *Tūi and kererū: Helping New Zealand icons in your backyard*. 2008 pamphlet produced by the Department of Conservation Southland Conservancy. <https://www.doc.govt.nz/>

### 2.3.5 Conserve natural areas according to ecological principles

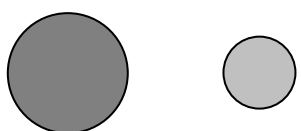
Patch size, shape, and connectivity are extremely important factors when determining which habitats to preserve for wildlife. Below are some general principles that really address conserving or creating new habitat in such a way as to benefit species that are specialists, e.g. they need a specific type of habitat. Usually, large, unfragmented natural areas are in short supply so ecologists tend to recommend conserving large patches over small. Wildlife species that seem to be declining tend to be specialists that do not do well in fragmented areas consisting of relatively small patches.

Better → Worse



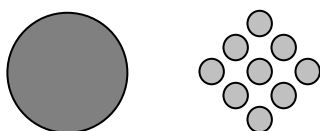
*Circular patches are better than other shapes.* This helps to minimise edge effects. Wildlife living in habitat edges tend to encounter higher levels of predation, more damaging human disturbances, and increased competition from other species. Remember, though, some wildlife and plant species (mainly generalists) prefer edge habitat and thrive in these areas.

Better → Worse



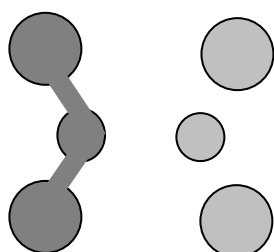
*Large patches are better than small.* As a general rule, bigger patches tend to have more species. Many species, such as some forest songbirds, primarily live in interior habitat during the breeding season. Generally, interior habitat will begin to appear in a circular preserve when it reaches 8 acres [c. 3 ha] in size (the point at which a circle exceeds 328 feet [c. 100 metres] in radius). How much of a patch is considered edge? Estimates vary, but an edge is estimated to extend 50-100 metres into a patch of habitat. Essentially, microclimatic conditions (soil moisture, temperature, etc.) are different on edges vs. interiors. At 90 acres [c. 36 ha] a circular reserve would contain as much interior as edge habitat. Nevertheless, patch size requirements vary according to factors such as species and natural community type. Even conserving a collection of small patches can help threatened and endangered species.

Better → Worse



*One large patch is better than several small patches with the same total area.* Simply totalling the area of preserved wildlife habitat on a development property is insufficient. Small, fragmented patches have more edge habitat and may not provide adequate space to sustain many New Zealand species. Some animals require large expanses of habitat to survive. Sometimes, though, a bunch of little patches of habitat located next to each other is fine for certain species (see also Box 5).

Better → Worse



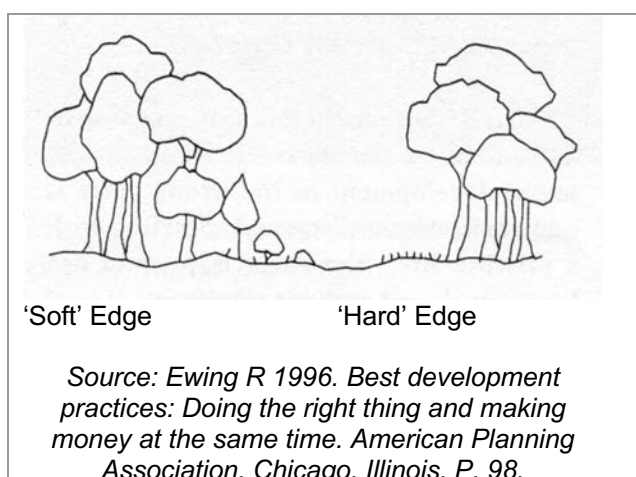
*Patches connected by wildlife corridors are better than those without.* Though some debate remains, most evidence shows wildlife corridors play an important role in the survival and stability of individual organisms, single species, and even entire ecosystems. It is best to make efforts to preserve habitat that has functional connections to other existing natural communities. Whenever possible, efforts should be made to coordinate habitat preservation with adjacent landowners. This can help to create a matrix of natural areas suitable for both localised and wide-ranging species. Linear corridors are particularly important for “walking animals” such as geckoes, skinks, beetles, and even kiwi. When incorporating wildlife corridors into your land management plans, use the following as general rules of thumb:

- Natural landscape connections long established and used as movement corridors for wildlife are better than new human-made connections.
- Wide corridors are better than narrow corridors. Interior conditions are typically maintained throughout the centre of wide corridors. In contrast, narrow corridors are typically all edge habitat.

- Corridors should include both dry and wet areas. The most productive corridors are typically in areas along streams and rivers (riparian areas). A majority of vertebrate species use these riparian areas at some point during their life cycles.
- Useful riparian corridors should include areas of terrace scarp forest on at least one bank in addition to the entire floodplain on both banks of streams and rivers. During flood events, animals can still use the upland areas.
- *Types of green corridors:* Rivers, streams, shelterbelts, hedges, field boundaries, road and rail verges, embankments and tracks may all act as preferential pathways for wildlife and plant dispersal. These linear features may be continuous (rivers) or fragmented (hedges) as stepping stones. Many terrestrial species are quite capable of flying from patch to patch. For a detailed look at how to build green corridors, see 'Establishing shelter in Canterbury with nature conservation in mind' 2003. Environment Canterbury and Isaac Centre for Nature Conservation.

Another option is mixed-species corridors allowing for some areas of indigenous dominance, some of exotic species, and other stretches with a combination – again reflecting the diverse heritage of the land. Predator control may be needed along these connective corridors as they may be used by pests as well as by native wildlife. In addition, these corridors could facilitate the movement of 'weeds' and care is needed to be aware of and monitor the potential spread of weed plants from other areas.

*Patches with 'soft' edges are better than those with 'hard'.* Wildland urban interfaces (WUI) with edges of gradual and undulating vegetation (soft) tend to buffer against disturbances better than those with straight and abrupt (hard) edges. This concept also applies to the transition between urban land uses and natural areas. In general, 'softening' the transition from a 'hard' urban use to a natural community or wildlife corridor is recommended. One example might be a landscaped community park or 'naturalistic' stormwater pond separating a parking lot from a protected natural area. It is important to understand that these edge transitions include minimising the diverse disparities between urban and natural areas such as the difference between highly lit urban areas and the low-light natural areas at night or the disparity between domesticated animals and the wildlife that they may disturb.



### 2.3.6 Conserve high-quality and rare natural communities

As stated earlier, biodiversity is a combination of species and genetic richness and natural community types. Each potential development property may have a number of different natural community types. Some natural communities may be of higher quality or rarer than others.

*In some cases, give priority to rare natural communities.* It is imperative to conserve remaining lowland natural communities even if they are degraded as most are highly threatened. However, one may have a range of natural community types across the proposed development site, and decisions have to be made where to conserve and where to build. For example, there may be very few kauri forest remnants left in a region and if kauri forest is on your site, you may want to give it priority and

build on other portions. In many cases, it may be that most natural community types are rare in the region and it will be difficult to prioritise any remaining remnants. Each decision will be unique to your parcel of land. Additionally, quantity is not necessarily better than quality. In some situations, a high-quality though somewhat common natural community may be preferable for preservation over a low-quality more rare community. This balance needs to be evaluated by an experienced ecologist.

*High-quality natural communities tend to have a high number of indigenous species and a low disturbance history.* Indigenous species are those characteristic of or prevalent in a particular natural community. Basically, indigenous species are very vulnerable to habitat loss as they are unable to survive in different natural communities. For example, a relatively undisturbed wetland may contain an assortment of indigenous birds, frogs, lizards, and plants. Such a high-quality wetland would be difficult to mimic if one were to fill it in and attempt to recreate the wetland in another section of the site. This is why in earlier sections of this manual we prioritised avoidance over mitigation of adverse effects on ecosystems. These wetland animals and plants would not be present in nearby, high-quality dryland areas because they are not adapted to such conditions. Plus, heavily disturbed areas (e.g. ones that had a history of human activity causing fragmentation of the habitat or pollution) are at risk of invasion (or have already been invaded) by exotic species. A predominance of invasive exotics within an area disrupts the conditions necessary for indigenous species survival.

It must be noted that every parcel of land and the regional context is unique. There is no established formula for determining which communities should be conserved and which are expendable. Each proposed development should undergo a thorough review by experienced natural-area specialists. These specialists can help your development establish the most balanced land-use design and management scheme possible. In addition, several New Zealand organisations and websites can provide information about New Zealand's major natural communities:

New Zealand Biodiversity Strategy (<https://www.doc.govt.nz/nature/biodiversity/te-mana-o-te-taiao-aotearoa-new-zealand-biodiversity-strategy-2020/aotearoa-new-zealand-biodiversity-strategy/>)

Department of Conservation (<https://www.doc.govt.nz/>)

Landcare Research (<https://www.landcareresearch.co.nz/>), and

### 2.3.7 Create a network of open space and nature parks

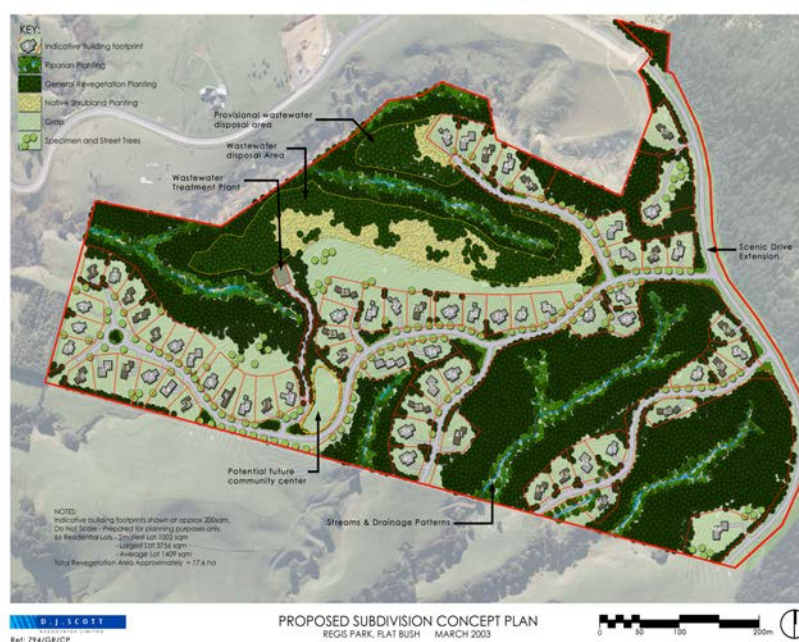
Where possible it is beneficial to create nature parks for the use and enjoyment of your development's residents. These areas can be used to help market your development by showing your commitment to creating public space and conserving the historical natural conditions of your site. Wildlife watching activities are very popular. In the USA, the National Park Service estimates over 40 million people participate in these activities within one mile [1.6 km] of their homes. This is almost one-third of all urban residents throughout the USA, and one could expect that many New Zealanders enjoy watching wildlife near their homes as well.

In 1995, American LIVES Inc., a San Francisco based marketing and research firm, conducted a survey on what American homebuyers desire in new residential developments. Their findings showed the growing importance of natural areas. 'Lots of natural, open space' and an abundance of 'walking and biking paths' were respectively listed as the number two and three most important features for new homebuyers, behind only 'neighbourhood designs featuring quiet and low traffic flows'. These were features not only desired but considered something worth paying a premium for. Wilderness areas that harbour plants and animals native to a neighbourhood's pre-developed parcel of land were also listed as valuable amenities. The effective integration of preserved natural communities, human-made nature parks and trails, and social interaction in what American LIVES termed the new 'outdoor living room' can bring additional profits to your development venture (see 1.5.3), while simultaneously conserving wildlife habitat.

Clustering built areas and constructing medium-rise dwellings can allow larger areas of public open or green space, which provides greater opportunities for core sanctuary habitat rather than small fragmented or linear features that do not have broad enough buffer zones (see example of a site

design, Figure 8)<sup>37</sup>. Vegetated open space so created must be legally protected, for example by covenant or public acquisition, to prevent future infilling, destruction of vegetation and loss of minimal patch density. Having these green areas connected in some way with minimal road crossings or public trails will benefit wildlife as disturbance by humans is decreased. When providing walking, cycling or horse-riding paths along linear features such as river flood plains, ensure that they don't take up only the best, most central and productive part of the corridor, but provide for representative protection of all the environment and the experience. Paths should have most of their length on the edges of corridors to reduce disturbance, fragmentation and edge effects.

In the cases where wildlife corridors are identified, homes along these corridors need to have special land management considerations. First, some kind of buffer needs to be established between the wildlife corridor and the back garden. The garden cannot just end at the edges of a significant wildlife corridor as noise, lights, and pets will disturb wildlife movement patterns. A buffer of about 10–20 metres should be situated between the backyard and the corridor. To allow the free movement of animals, no fences should be allowed in this buffer or corridor. In particular, humans and pets should be strictly forbidden to walk within the corridor/buffer as this will disturb animals. People purchasing homes in these areas should be educated about the importance of these wildlife corridors and help with the maintenance and 'watching out' for neighbours and pets that may access these wildlife corridors and underground crossings. With an engaged community, a connected open space system can be designed and managed for both people and wildlife.



**Figure 8** Concept plan for Regis Park subdivision of Flat Bush development (Manukau City). Designer – DJ Scott, 2003

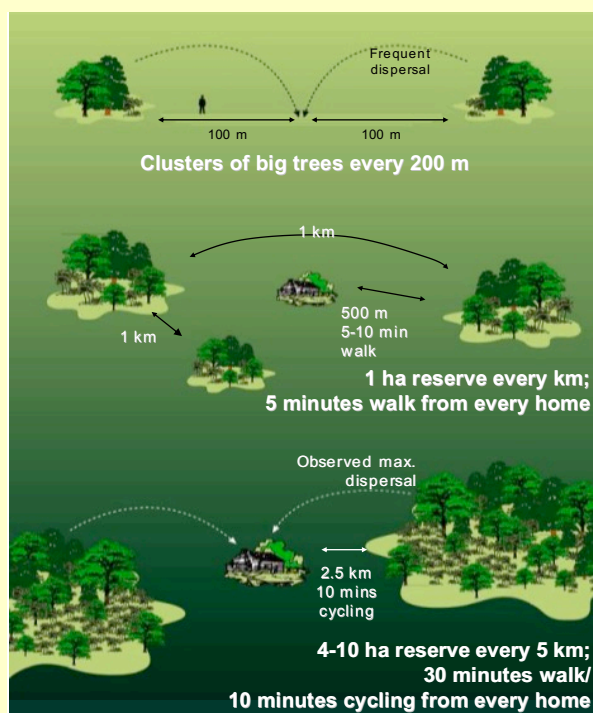
<sup>37</sup>The Flat Bush development (and in particular Regis Park, figure 8) in Manukau City (<https://regispark.co.nz/>).

### Box 5 Case study: Importance of native patches in New Zealand urban environments

Within New Zealand, we now have a better understanding of forest dynamics across the landscape and how to integrate nature and production. This is based on observing and modelling dispersal, regeneration and forest succession processes. By linking this to theory of ideal reserve design (in terms of size, shape, spacing, and connectivity) we can plan optimal forest patch configurations for cultural landscapes that ensure their ecological and cultural sustainability. This means that indigenous nature is always visible and accessible to the community – so everyone grows up experiencing, knowing and wanting to protect it. Natural heritage is also projected to visitors and becomes associated with sense of place.

From measurements and computer modelling, we have determined minimum targets for forest patch size and density, for rural and New Zealand urban environments. These should achieve ecological integrity on the one hand and cultural visibility, accessibility and identity on the other. This configuration is built around a pattern of nested patches of various sizes that are known to provide minimal security for a range of plants, including those that are frost- or wind-sensitive, and at least the more common iconic wildlife – fantails, bellbirds, tūī, kererū, tomtits, brown-creepers, lizards and invertebrates. Auckland, Christchurch, and other city councils are adopting a nested patch approach to the design of their urban environments.

Patches > 6 ha at about 5-km spacings  
 Patches > 1 ha at about 1-km spacings  
 Groves of 0.02 ha at about 200-m spacings



*Stepping stone distances for wildlife and accessibility for people Source: Meurk & Hall 2006, New Zealand Journal of Ecology*

### 2.3.8 Create a green transportation system

Placing roads through natural areas and wetlands will further fragment the landscape; have a design that is sensitive to conserved or restored areas. Roads in residential neighbourhoods can be designed to minimise impacts on nearby natural areas, and even contain additional wildlife habitat. Street swale construction, planting of native trees and tussocks, a meandering street form, traffic calming devices, and decreased impervious surfaces (see Figures 9 and 10) will create a walkable and safer street layout that diminishes the dominance and speed of cars (benefit for both wildlife and humans alike!). Vegetation softens street edges, creates additional habitat for wildlife and a more interesting and varied streetscape, while filtering stormwater runoff (more about this in Section 2.4.6).



**Figure 9** Seattle street-edge alternatives. Photo: Maria Ignatieva



**Figure 10** *Narrow roads with street trees, Lincoln, Christchurch.*  
*Photo: Robyn Simcock*

*Roads and aquatic animal movement:* If roads cut off connections between waterbodies (e.g. wetlands or streams), this will restrict the ability for aquatic species (e.g. fish) to disperse from one waterbody to another. Isolated and fragmented populations of aquatic animals are prone to local extinction and the regional health of aquatic populations is somewhat reliant on the ability of animals to travel from one place to another. The first step is to identify which aquatic species in the area may need culverts; this will vary depending on location and surrounding habitat. One should hire a local aquatic biologist to not only identify such animal species but to locate areas where aquatic organisms may cross under a road. Once important aquatic connections are identified, several options are available. The best solution is to re-route roads based on important connections between streams and wetlands. When this is not possible, some kind of below-road culvert may be required. Following are some important considerations for culverts:

- For the movement of most native freshwater fish, wetlands and other waterbodies must be connected by streams at least 10 cm deep. Note that long stretches of fast-flowing or polluted water, flap gates, or overhanging culverts act as impassable barriers to effective fish movement. To permit effective fish movement, rough up the smooth bottom of culverts with cement or rocks to slow water flow<sup>38</sup>.
- Be aware that culverts may be used by mammalian and aquatic predators (e.g. possum, eels, and trout) and one may have to implement a predator control programme to benefit native animals such as Canterbury mudfish *Neochanna burrowsius* (these mudfish are eaten by eels). In some cases, one may not want to connect a pond that has mudfish to a stream or river that contains eels.
- For more technical information on culvert designs for safe fish passage, see the Department of Conservation's 1999 document – Fish passage at culverts: A review, with possible solutions for New Zealand indigenous species<sup>39</sup>.

<sup>38</sup> See Wildlife in Canterbury Wetlands <https://www.doc.govt.nz/nature/habitats/wetlands/wetlands-by-region/canterbury/#:~:text=Canterbury%27s%20wetlands%20are%20a%20haven%20for%20migratory,found%20no%20where%20else%20in%20the%20country.>

<sup>39</sup> Fish document Web site – <https://www.doc.govt.nz/fishpassage>

### 2.3.9 Consider nearby habitat and people

Each potential development property is as unique as the natural communities that exist there. As mentioned before, sometimes certain areas bordering the property are of special value and one may want to implement management plans and/or create conserved areas near habitat residing outside the site. For example, a species of special concern may be located in habitat just on one side of the property and warrants creating a buffer of habitat along this border and restricting access to the area. In addition, rare habitat or habitat of local interest may be found on one side, and so creating a patch of new habitat will make this area larger. In some cases, corridors may be warranted to connect natural areas that lie outside the boundaries of the property, facilitating the movement of plants and animals.

Also, pay attention to the catchment context of a site as there will be receiving-water-ecosystem consequences of any development. You should not focus on just the land within the boundaries of the proposed site. Decisions made within a site can impact surrounding lands and people. Listening to the concerns of people living nearby and involving them in discussions about the proposed development can promote positive community involvement. Broadening the scope of the plan to include surrounding peoples and landscapes will ultimately help in goals being achieved to benefit the entire city, district, or region.

#### Box 6 Catchment approach

One useful concept is to look at an area as a catchment for water (sometimes referred to as a watershed). As pointed out by van Roon and Knight (2004)<sup>40</sup>, one of several options for responding to the need to manage human interactions on ecosystem structure and function is to use the catchment as a management unit. This reduces cross boundary complexity. A catchment can be defined by water flow. Rain landing on vegetation or the ground either percolates into the ground, evaporates, or overland flows via creeks and streams into rivers, lakes, estuaries, swamps or coastal water bodies. Plants take up water, and this eventually evaporates or is transpired back into the atmosphere. As a rough guide, the ridgelines surrounding a water body can be used to indicate the limits of the catchment. For example, the headwaters of a river will often (though not always) be the upper limit of a catchment. Some water entering the ground and not taken up by plants enters aquifers or groundwater. This water can eventually emerge at another point, such as into a lake, stream or wetland, into the coastal or marine environment, or adjacent catchments. Catchments can be small for creeks or ponds, or large for rivers and lakes. In addition, creek and pond catchments can be part of river and lake catchments, hence forming subcatchments. Whether a unit is considered to be a catchment or subcatchment depends on the scale being investigated.

Overall, the catchment concept sits comfortably with regional government management regimes and it has a legitimate biophysical grounding. The operationalisation of catchment management can be scaled up to bioregions/ecoregions, or down to subcatchments, remnant ecosystems and ecotones. In flat areas, catchment boundaries will be nearly imperceptible rises between headwaters of adjacent streams.

'Catchment approaches allow for a recognition and consideration of where (urban) growth distribution should occur. Consideration of land use from a catchment perspective allows for a greater awareness of the cumulative impacts of catchment development. A comprehensive approach to resource protection can be developed and implemented, based on consideration of catchment-specific issues such as steep slopes, erodible soils, existing bush retention, high water table, the need for aquifer recharge, etc. A catchment approach allows for developers and the general public to understand the basis on which land-use decisions were made in a rational format, . . . Land-use decisions based on

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<sup>40</sup> van Roon M, Knight S 2004. Ecological context of development. New Zealand perspectives. Oxford University Press, Melbourne, Australia.

catchment-wide analyses provide the territorial authority with a basis for making decisions that can be defended' (Shaver 2000, p. 15)<sup>41</sup>.

A catchment approach can cross many natural community types and involve a multitude of stakeholders (e.g. farmers and urban residents); managing multiple land uses and involving multiple stakeholders is called Integrated Catchment Management (ICM). ICM helps address the need for multidisciplinary and interdisciplinary approaches to resource management. But ICM has weaknesses, for example, catchments may not necessarily encapsulate whole ecosystems. For example, biodiversity management sometimes means dealing with tracts of land and water over areas far larger than individual catchments. This is because the processes involved in maintaining viable populations of birds and trees may operate over vast areas. Mammals, birds, and even butterflies travel between catchments and may migrate across continents. Therefore, catchment approaches should be flexible, with boundaries delineated according to the issue being tackled.

For subdivisions located near birds or other wildlife species that are sensitive to human disturbance, developers should look into creating buffers between the homes and the wildlife habitat. In many cases, specific management may be required to minimize the impacts of people, such as an education plan that engages residents on appropriate behaviours (see section 2.5.1) or restricting access to the critical habitat during the breeding season.

### Box 7 Case example: Waipu Spit Refuge, people, and shorebirds

Studies have indicated that human disturbance can affect the breeding and foraging success of shorebirds. For example, the presence of humans adversely affected the foraging behaviour of New Zealand dotterel chicks (*Charadrius obscurus aquilonius*)<sup>42</sup>. The Waipu Spit Refuge (Northland) contains a significant number of threatened shorebird species, including New Zealand dotterel (*Charadrius obscurus*), variable oystercatcher (*Haematopus unicolour*), white-fronted tern (*Sterna striata*), Caspian tern (*Sterna caspia*), and New Zealand fairy tern (*Sterna nereis*). There is concern about the increase of subdivision development in the area as the increase of human visitors could impact the breeding success of shorebirds in this refuge<sup>43</sup>. The Department of Conservation is currently studying ways to minimize human disturbance by restricting access to certain areas of the refuge and educating users about the dangers to breeding shorebirds.



White-fronted tern and chick Photo: Landcare Research

<sup>41</sup> Shaver E 2000. Low impact design manual for the Auckland Region. Technical Publication 124, Auckland Regional Council, Auckland, New Zealand.

<sup>42</sup> Lord A., Waas J. R., and Innes J. 1997. Effects of human activity on the behaviour of New Zealand Northern dotterel *Charadrius obscurus aquilonius* chicks. *Biological Conservation* 82: 15-20

<sup>43</sup> Pierce R. J. 2000 Implications of a subdivision proposal near an important shorebird breeding site. Conservation Advisory Science Notes No. 274, Department of Conservation, Wellington.

### 2.3.10 Conserve wetlands



*Liffey Stream, Ryelands neighbourhood, Lincoln, New Zealand (note native vegetation along banks).  
Photo: Meryl Klein*

The vast majority of New Zealand's wetlands have been drained or irretrievably modified for coastal land reclamation, farmland, flood control, and the creation of hydroelectricity reservoirs<sup>44</sup>. This occurred mostly between 1920 and 1980 but still continues to a limited degree in some areas. The rainwater which would normally pond and seep slowly into the surrounding waterways is now swiftly carried to rivers, reservoirs and lakes by hundreds of kilometres of ditches and channels. Cattle now graze where water birds once waded, and weeds, eutrophication and pollution have reduced the biodiversity of many surviving wetlands. Only the high-altitude wetlands have escaped this process. Several attempts have been made to estimate the extent of the wetlands' decline. Soil type is a useful guide to the original wetland area because many vanished wetlands left distinctive soil types. Landcare Research scientists used soil maps to estimate that the original area of freshwater wetland was approximately 672,000 ha. An earlier estimate, which included saltwater wetlands such as estuaries and salt marshes, put the original wetland area at over one million hectares.

The area of wetland that remains today cannot be simply calculated from maps because it has been shrinking yearly. Between 1954 and 1976, surveys by the former NZ Wildlife Service found that 263 000 hectares were lost – a rate of nearly 12 000 hectares per year. Resurveys of sample areas in Northland indicated that between 1978 and 1983 approximately 15% (3175 ha) of the remaining wetland had been drained. These surveys ceased in the mid-1980s when the Wildlife Service became part of the newly established Department of Conservation. The Department subsequently set up a wetland inventory which lists about 3000 wetlands (see <https://www.doc.govt.nz/documents/science-and-technical/nzwetlands00.pdf>).

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<sup>44</sup> This introductory section was adapted MFE's The State of New Zealand's Environment – The state of our waters 1997 see <https://environment.govt.nz/assets/Publications/Files/ser-1997.pdf>

The long-term health of nearby wetlands is contingent on site designs and construction practices. The layout and placement of roads and buildings throughout your development will have a substantial impact on the health of conserved or restored wetlands. The best way to conserve wetlands on your parcel of land is to design around them entirely. Outright protection is primarily the province of other acts (e.g. the Marine Reserves Act, the Reserves Act 1977, the National Parks Act, and the Conservation Act 1987) but some protection under the Resource Management Act can be achieved through policies and rules in a district plan (section 76), or a Water Conservation Order (sections 199 to 217). All decisions made under the RMA must, as a matter of national importance, recognise and provide for the preservation of the natural character of the coastal environment, wetlands, lakes, rivers, and their margins.

### **2.3.11 Conserve drained margins around wetlands and natural water bodies**

Moderately-drained land generally does not share the same protection status as New Zealand's wetlands or water bodies. Yet shorelines are typically prized by developers. The real-estate value of such land has contributed to a rapid decline in their prevalence and quality. Further, such lands located near water are of importance because they are essentially buffers that minimise impacts from surrounding land use (e.g. stormwater runoff coming from impervious surfaces). When developing near wetlands and waterways it is essential to create buffers, especially along the watersheds that drain into the wetlands. No homes, backyards, or disturbances should be placed within these buffers. This allows access to the natural areas for management activities while preventing homeowners from encroaching into them.

The health and biodiversity of your development's wetlands are highly dependent on the health of the dry habitats surrounding them. Buffers provide many benefits to wetlands and natural water bodies. They can help to minimise erosion and sedimentation while controlling water temperatures and contributing woody debris. They also help to filter out pollution and excess nutrients from groundwater. From a wildlife perspective, buffers supply food and cover for many species that require wet and dry environment connectivity. Anticipating the type of activities that will take place on buffers, in both natural and built environments, will help you to address any issues that might affect the lower-lying wetlands. Runoff from dryland activities can have both beneficial and harmful effects on the lower-lying wetlands and natural water bodies. Clean waters with minimal silt and pollutants benefit many of New Zealand's aquatic organisms, including insects, fish, and birds. Note, some plants and animals are adapted to highly eutrophic (i.e. high fertility) swamps and waterbodies; however, others are adapted to oligotrophic (i.e. low fertility) conditions such as acid peat bogs.

Whenever possible, connect adjacent wetlands with broad buffers. Buffers need not be the same fixed width around the entire wetland. The minimum upland buffer required to ensure healthy wetlands varies greatly between each specific natural community and according to local and regional government recommendations. Consult local government policies and wetlands specialist to provide the optimum buffer for your valuable wetland amenities.

### **2.3.12 Enhance Māori values in urban and rural environments<sup>45</sup>**

Māori may have a significant relationship (traditional and contemporary) with particular geographic areas within urban or rural lands that are being considered for development. Developers and landowners may want to explicitly involve Māori in the planning process.

#### **Goals**

- Protection and enhancement of Māori cultural heritage including cultural sites, traditional pā sites, marae, papa kainga, archaeological sites, wāhi tapu (sacred sites), mahinga kai (food source areas), traditional landscapes, water and coastal areas
- Social and economic infrastructure provided and maintained
- Cultural identity maintained

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<sup>45</sup> Adapted from an internal Landcare Research document authored by Clare Feeney and Garth Harmsworth

- Natural and built infrastructure services are provided in ways that protect cultural heritage, give due consideration to customary interests in natural resource use, and allow participation of Māori in decisions regarding natural resources as Treaty partners

**Design measures could include:**

- Strategically introduce native vegetation and taonga species to culturally significant areas to enhance cultural values, and to reduce runoff and stormwater, increase use and application of rain gardens using taonga species, recreate habitats based on Māori values
- Reduce disturbance and modification to culturally significant areas (e.g. pā, papa kainga, wāhi taonga, wāhi tapu, mahinga kai, wāhi kaimoana) using low impact design and development
- Reduce biosecurity risks to cultural areas and indigenous ecosystems, by involving tangata whenua and urban groups in pest management strategies and operations
- Promote safe, healthy traditional food source areas within, and adjacent to, urban areas, particularly those close to marae, papa kainga, and Māori community areas
- Promote safe, healthy recreational areas within urban areas, particularly those close to marae, papa kainga, and Māori community areas
- Minimise and eliminate contamination to culturally significant areas, such as traditional food source areas, through advanced environmental technologies, design and planning
- Design and use of natural systems (e.g. wetlands, streams) to enhance cultural sites
- Design culturally appropriate sewerage reticulation, sewage disposal and effluent treatment, and eliminate sewage from directly entering waterways and coastal areas
- Increase connectivity between cultural sites and indigenous ecosystems during development
- Recreate natural ecosystems in combination with protecting culturally important sites within urban environments, and increase linking of cultural sites to indigenous biodiversity sites
- Define cost-effective low impact approaches to design and development, and identify and minimise development factors adversely impacting on Māori, increase culturally tailored development strategies that improve Māori housing areas and Māori housing design
- Work with Māori communities to improve energy efficiency strategies, as a contribution to wider population strategies
- Improve transport systems /roading design to take into account Māori values and communities

**Proactive involvement of Māori could include:**

- Restoration and enhancement projects that fulfill Māori aspirations and outcomes
- Restoration and enhancement of cultural use areas specifically designed for traditional purposes such as food production, weaving, carving, taonga enhancement, and other cultural uses
- Enhancement or recreation of special taonga habitats, in line with Māori aspirations for increasing certain native species (e.g. native birds, native fish, reptiles, insects) within urban environments
- Sharing knowledge and understanding between Māori and mainstream groups such as scientists, planners, policymakers, researchers, and promoting the complementary use of Māori, science, and other knowledge systems
- Māori education within urban environments, and increased knowledge and understanding of Māori culture
- More use of Te Reo in urban environments, which can be developed in conjunction with low impact design and development strategies, such as use of bilingual signs, building and roading design, restoration and enhancement projects, use and promotion of place names, narrative stories, Māori history
- More use of Māori art in visual art forms that enhance urban design and development and promote cultural awareness, understanding, and pride in urban environments and New Zealand biculture

## 2.4 Phase II: Construction



*Constructing a New Zealand subdivision. Photo: Mark Hostetler*

In Phase I, goals are determined and the design primarily dictates where built areas and conserved/restored areas are located. As part of the construction process (Phase II), several design and management practices need to be considered to insure that the goals for the project are realised and that minimal impacts occur to onsite and surrounding habitat. Several of the following ideas and practices follow Low Impact Urban Development practices and are adapted directly from an urban greening manual<sup>46</sup> titled *How to put nature into our neighbourhoods – application of Low Impact Urban Design and Development (LIUDD) principles, with a biodiversity focus, for New Zealand developers and homeowners.*

Key steps during construction for biodiversity and environmental sustainability are:

1. Choose the right plants for the right place (emphasise natives)
2. Understand basic planting techniques for large and small spaces
3. Reduce lawns
4. Install dark-sky lighting
5. Implement tree and native area protection during construction
6. Use low impact development techniques for stormwater treatment
7. Install efficient irrigation systems
8. Reduce, reuse, or recycle materials on site
9. Use trained contractors and subcontractors

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<sup>46</sup>Ignatieva M, Meurk C, Van Roon M, Simcock R, Stewart G 2008. Landcare Research Science Series No. 35. Manaaki Whenua Press, Lincoln, New Zealand.

### 2.4.1 Choose the right plants for the right place (emphasise natives)



*Example of an urban native garden, Motukarara Native Plant Nursery, Christchurch, Canterbury.  
Photo: Mark Hostetler*

Planting natives will help improve indigenous biodiversity because many of our local plants have disappeared or are in precariously low numbers; In addition, local animals are adapted to utilise native plants whereas most exotic species are functionally sterile for native wildlife. **Using native plants is a very important decision that can have a positive impact on biodiversity and natural character on your site.** In addition, native plants are adapted to local soil and climate conditions; in most situations, an environmental benefit is realised as people will eventually use less fertiliser, pesticide, and water. Many exotics are quite pre-adapted to local site conditions and will do just as well as a native plant, but some exotics (e.g. roses) require extra water, fertilisers, and pesticides for their maintenance and some become biodiversity risks.

While the focus here is unashamedly on our special indigenous plants and wildlife, it is not forgotten that our economy and much of our quality of life is dependent on exotic species. These plants are the basis of our food and timber production, and amenities (shade, shelter and aesthetics). Many imports have become pests so we have to deal with the 'bad' while nurturing the 'good'. The goal here is therefore not to indiscriminantly replace exotic 'nature' with native nature, but rather to raise the profile of the indigenous, welcome the useful and beautiful immigrants, and endeavour to eliminate or control the biosecurity risks. Some exotic plants provide valuable food resources for native birds. For example, Australian gums and proteas and South African red hot poker produce copious nectar for our honey-eating birds, often in autumn and early winter when other food is in short supply.

On the other hand, kererū love holly and ivy berries but these (also cotoneasters, cherry laurel, yew and plums) get transported into native forest, germinate and, because they happen to be shade-tolerant and sometimes evergreen, grow up through the understorey and threaten the integrity of the bush. So we need to be selective and intelligent about how we handle the threats. For instance if holly

is the only food for kererū in a part of the city, it would be 'cutting off our nose to spite our face' to suddenly cut down these trees. Rather we should have a transitional strategy to establish native or safe alternatives and then progressively eliminate the baddies. Invasive, weedy species to avoid include sycamore, silver birch and plane trees (both with allogenic pollen), rhododendrons (poison nectar that affects honey), ivy, holly, yew, tradescantia, aluminium plant, periwinkle, stinking iris, plums, black locust, barberry, cotoneaster, Mexican daisy, barberry, and honeysuckle. In northern parts of New Zealand there are many more seriously invasive species, including wild ginger, exotic palms, woolly nightshade, monkey apple, privets, agapanthus, pampas grass, moth plant, mist flower (more about invasive exotics in 2.5.4).

Successful planting of both native and exotic species needs to not only match plants to the district's landforms and soils, but also to local site conditions. Sometimes, fill, topsoil and other construction activities may alter the soil and certain native plants may not fair well. Other primary requirements that affect plant growth include the type of soil and moisture holding capacity, drought and frost tolerance, soil fertility, frostiness of the plant, and exposure. In particular, exposure to drying winds during the summer and frost in winter can have a primary influence on survivability, even if soil conditions are good. The other factor that will determine success and failure is presence and activity of browsing mammals (especially in rural areas). Moisture limitations can be overcome to some extent by irrigation, but this should be used sparingly and ideally only during establishment of plants. Excessive watering can cause the plants to grow shallow root systems, and when a drought does occur, they will have a difficult time in surviving.

Usually you need a local soils expert to identify the types of soil on your site. The types of soil in your area can be found at <https://soils.landcareresearch.co.nz/>. This is relevant because certain plants do well in particular soils. It is preferable when using native species that have a local representative (e.g. lacebark or kōwhai) to use local genetic sources. Called ecosourcing seed, this preserves the genetic integrity of local populations and helps contribute to regional biodiversity (<https://www.landcareresearch.co.nz/news/new-guidelines-suggested-for-ecosourcing-seed/>).

One should select certain plants for different parts of your property; an excellent guide<sup>47</sup> is available that recommends native plants for use in these following areas:

- Street trees for avenues, parks, and traffic islands
- Home gardens
- Rock gardens
- Forbs and ferns for shady public parks and private gardens
- Plants for walls and roofs
- Riparian zones and water features

Where does one obtain native plants? This website can direct you to local native plant nurseries – <https://nznativeplantnursery.co.nz/>. Also, for streamside plantings, suitable species for various zones are detailed in various streamside planting guides (e.g. CCC Parks & Recreation guide – <https://ccc.govt.nz/assets/Documents/Environment/Water/StreamsidePlantingGuide-streamsideplanting.pdf>.)

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<sup>47</sup> Ignatieva M, Meurk C, Van Roon M, Simcock R, Stewart G 2008. How to put nature into our neighbourhoods – application of Low Impact Urban Design and Development (LIUDD) principles, with a biodiversity focus, for New Zealand developers and homeowners. Landcare Research Science Series No. 35. Manaaki Whenua Press, Lincoln, New Zealand.

## 2.4.2 Understand basic planting techniques for large and small spaces



*A beech forest under passive restoration, Hinewai Reserve, Banks Peninsula*  
<https://www.hinewai.org.nz/> Photo: Mark Hostetler

### Large spaces

**Why restore?** Each person or community may have different reasons for restoring an area. Voluntary and/or regulated efforts for ecological restoration may originate at the private individual, catchment, city, district, region, or even national level. For example, a private landowner may choose to restore streamside habitat for fish and avian species. A community may wish to restore all riparian forest corridors throughout a catchment to improve the health of stream and harbour ecosystems. A city like Nelson may choose to restore an unused urban site to a historically desirable natural area to help minimise some of the loss of bird diversity in the area. A district may choose to restore a degraded upland habitat to benefit from ecosystem services such as aquifer recharge. It may even be cultural or aesthetic values that give the impetus to return a section of land to its original composition of plants and animals. One unique New Zealand example of private land being restored is Hinewai Reserve, Banks Peninsula (<https://www.hinewai.org.nz/>). This 1000-ha piece of land has gone through extensive natural regeneration with rigorous browser and predator control.

Planting in semi-wild situations where there may be limited maintenance, irrigation, etc. requires quite a different approach to gardening in protected and nurtured locations. For example, one has to consider stock fences and predator control to help young tree and bush seedlings to become established. Often groups of people are quite enthusiastic about planting natives and one can organise local residents to help out (Figure 11). As mentioned previously, several organisations can provide advice and some funding to help landowners control pests and plant native vegetation ([www.landcare.org.nz/](http://www.landcare.org.nz/); <https://www.landcareresearch.co.nz/>; <https://www.doc.govt.nz/>). To learn more about specific management practices to help young seedlings survive, see section 2.5.



**Figure 11** As part of a restoration project, volunteers are planting natives on Quail Island, in Lyttelton Harbour Photo: Mark Hostetler

*Using exotics for native plant regeneration:* An important step to consider when restoring an area is to manage for the growth of natives underneath existing exotic species. If exotic plants are not listed as a weed (and there is no danger of it spreading into natural areas), then the exotic could become a 'nurse plant' to native seedlings. Such nurse plants protect native seedlings from frost and drying winds. In addition, removing large overstorey trees (e.g. crack willows) can cause additional problems; for example, removal of willows along stream banks can cause (through exposure to sunlight) the regeneration of blackberry and grass – making it difficult to interplant with natives. A better method is to leave the willows and plant natives underneath them. Once the native plants have established themselves, then remove or poison in situ the large overstorey trees.

In some cases, even weed species can be used successfully to regenerate native plants. Given certain conditions in the eastern South Island, native forest can develop through gorse, broom, and other shrub weeds. The shrub weeds act to suppress grasses and other potential weeds, allowing native plants to germinate. Later, these shrub weeds protect seedlings and saplings from the elements such as frost and wind. However, this only works if:

- The site is not too dry and a native seed source is nearby
- Domestic and wild animals are excluded from the area
- Fire is not allowed as broom and gorse thrive after a fire

An excellent online guide to restoration on large properties (*Protecting and restoring our natural heritage: a practical guide*) can be found on the Department of Conservation's website<sup>48</sup>. See Department of Conservation website (<https://www.doc.govt.nz/get-involved/run-a-project/restoration-advice/native-plant-restoration/>) for sourcing and growing local plants for your region.

### Small spaces

Plants around a home and section need to be planted in a specific way to minimise management over the long term. Below are some common installation mistakes made by landscapers<sup>49</sup>:

<sup>48</sup> See <https://www.doc.govt.nz/about-us/science-publications/conservation-publications/protecting-and-restoring-our-natural-heritage-a-practical-guide/>

<sup>49</sup> Adapted from University of Florida's *Florida yards & neighborhoods*, original author Dr Greg Davis

- Mistake #1: Overplanting

Small trees and shrubs are often planted too close together to get a 'full' look. The result, several years later, is a crowded landscape. Plants then must be removed or drastically pruned to reduce competition.

**Solution:** Beware of 'instant landscape'. The landscape architect should account for the mature size of plants and give them room – and time – to grow.

- Mistake #2: Lawn areas are cluttered with trees and shrubs.

Plants scattered throughout the lawn appear disorganised. They also create maintenance problems in terms of mowing, raking and giving plants the amount of water they need.

**Solution:** Group shrubs and trees in mulched plant beds bordering the lawn.

- Mistake #3: Shrubs around the home are too tall.

When plants grow too tall, they cover windows and no longer enhance the home's appearance. The only way to compensate for this 'misplanting' is by shearing to control the plant size. This constant shearing sometimes weakens and disfigures shrubs. It also creates extra work and yard waste.

**Solution:** Select foundation plants with an ultimate (mature) size that fits their location. Instead of shearing shrubs, selectively clip stray shoots to keep the plant neat and full.

- Mistake #4: Plants are planted too close to the house.

Plants too close to the house have an unattractive 'cramped' look. They also create a maintenance nightmare when it's time to repair or paint the house.

**Solution:** Foundation or corner shrubs should be planted half their mature width plus one foot away from the wall. Therefore, a shrub that will grow to be 2.6 metres wide should be planted 1.6 metres (= 1.3 + 0.3) away from the house.

### 2.4.3 Reduce lawns



*Typical suburban lawn Photo: Mark Hostetler*

Lawns can require a lot of time and expense, and associated activities such as fertilising, herbicide, watering and disposing of clippings. These are bad for the environment. A lot of fuel is used to mow lawns, and lawnmowers (because of their engine design) typically emit more pollution than automobile engines. A primary thing you can do to increase biodiversity and attract endemic species is to reduce the amount of lawn and replace with native species.

By avoiding excessively large areas of lawn and introducing native grasses and ground-hugging species, we can create areas that are as visually pleasing and functional as traditional lawns while providing a safer, less wasteful, and more biodiverse environment for both ourselves and our native fauna. Locally sourced native species are particularly adapted to our environment and potentially require little fertiliser, water and mowing once established. Even portions of the lawn could be delegated as vegetable gardens to increase local food production. A mixture of vegetable gardens, lawns, and native areas within a section can meet the needs of a family and increase the diversity of plants and animals.

An alternative is the biodiverse lawn. Many lawns already include native species such as *Hydrocotyle* and *Leptinella*. Therefore a quick and easy way to increase biodiversity is to plant other native species such as *Pratia* and *Dichondra*. One could still mow the lawn but it would contain a mixture of exotic grasses and native plants. For more species, check Landcare Research's manual *How to put nature into our neighbourhoods...*

#### 2.4.4 Install dark-sky lighting

For lighting along roads, utilise lights that are shielded from the sky and pool the lighting onto the ground. Dark-sky standards<sup>50</sup> utilise full cut-off illumination that shields light from being emitted upwards toward the night sky or surrounding natural areas. To be fully cut-off, the light bulb should not extend below a lamp shade (and use energy efficient light bulbs such as compact fluorescents). The idea behind such full cut-off illumination is to reduce night pollution so that people can view the night sky. In addition, bright lights threaten wildlife by disrupting biological rhythms and interfering with the behaviour of nocturnal animals. For example, artificial lights can alter frog foraging and calling behaviours and some bird species do not like to nest or roost in and around bright lights. Migrating seabirds can be lured into cities by lights and they can become lost and disoriented<sup>51</sup>. One may want to shield road or home lighting away from critical wildlife habitat or bird flight paths. For more information on New Zealand dark-sky efforts, see The Royal Astronomical Society of New Zealand ([www.rasnz.org.nz/darkskies/](http://www.rasnz.org.nz/darkskies/)).

#### 2.4.5 Implement tree and natural area protection during construction

It may be that the site contains significant mature trees and natural areas that warrant protection. These trees and areas may have been identified during the design phase but it is critical how one manages the site during the construction phase as to whether these native trees or natural areas survive over the long term.

##### Trees<sup>52</sup>

Trees and their root systems must be protected from damage during the construction process. Tree roots absorb essential water and nutrients. Use fencing to prevent heavy vehicles, such as trucks, from damaging trunks and running over the root zone causing soil compaction. Pay special attention to how much of the area around the tree was protected. It's not enough just to place a fence or flagging around the trunk of the tree. The roots underneath the drip line (the outer edge of the leafy canopy) should be protected by a sturdy fence. Even this still means that 50% or more of the roots will be impacted by construction. The single best factor that will help ensure the survival of a protected tree is irrigation. Stressed trees need plenty of water during the construction process and this means watering each tree to a soil depth of 30 cm about 2–3 times per week. Apply 10–15 cm of organic mulch within the tree protection zone to help maintain soil moisture; the mulch should not be up against the tree trunk. Next, roots need to be pruned at the edge of the tree protection zone. A trench 45 cm deep needs to be dug around the outside of the tree protection zone with an air spade (i.e., use compressed air) and cut the roots cleanly with a saw. Lowering or raising the soil grade around trees

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<sup>50</sup> See [www.darksky.org/](http://www.darksky.org/)

<sup>51</sup> Short notes. 1998. Two seabird recoveries from Christchurch city: implications for Classified Summarised Notes. *Notornis* 45: 153-55.

<sup>52</sup> Primary source: Ruppert KC, White C, Dessaint P, Gilman E, Foerste E 2005. Trees and construction: keeping trees alive in the urban forest. Program for Resource Efficient Communities. University of Florida, Gainesville, FL.

(particularly in the tree protection zone) even a few centimetres can effectively kill the tree. Lowering the grade a few centimetres removes important root mass and raising the grade a few centimetres smothers the roots and prevent oxygen from reaching them. Finally, under no circumstances should heavy machinery be allowed to run over the soil within the tree protection zone. Over 90% of the relative compaction of the soil occurs within the first three passes. Generally, hiring a certified arborist to oversee tree management can go a long way to protecting the health of preserved trees.

Soil compaction is not the only hazard. Dumping fill on the soil around a tree can have a similar deleterious effect and so can paving over the soil. Other impacts can involve the placement of utilities. Typically, most utility lines (cable, telephone, etc.) are laid by digging trenches throughout the site. If the site is heavily forested, trenching can impact a large number of roots. The best solution (and most cost effective) is to lay the utilities beneath the roads in the subdivision.

In some cases, a road, footpath or some type of pavement may be placed near the tree, causing some compaction. Depending on the tree species, a portion of the root zone could be compacted or paved over and the tree will remain healthy. If you see a tree that is located near construction, note how much of the root zone was protected. Ask a tree expert about the ability of that tree species to withstand soil compaction or pavement underneath the drip line.

How construction debris and chemicals are discarded is important; there should be designated zones for their disposal, away from any trees meant to be preserved. This debris can be toxic or can change soil pH due to leeching of chemicals into the ground.

Tree pruning is important. The landscape architect should know the proper ways to prune a tree so that it remains healthy. One of the worst pruning methods – and unfortunately still too commonly used – is called ‘topping’, where large branches at the top of the tree are simply sheared off, without regard to location or diameter<sup>53</sup>. This method can cause decay in the branch stubs and trunk, weaken roots, and attract pests. Sprouts that form from topped trees are poorly attached and can break off.

### Natural areas

With regards to protected areas, what kinds of management strategies have been implemented, both during the construction phase and post-construction? At a minimum – as required in many areas by law – there should be *well-maintained* silt fences around any wetlands or water bodies to prevent silt from entering these areas during construction. Runoff can carry vast amounts of silt into a wetland and essentially choke this system to death. Now, well-maintained is the operative word here. Check around the construction site. Are silt fences properly placed? Have any fallen down or been damaged?

Has some kind of natural buffer or transitional zone been established between human-disturbed areas and the protected areas? If the protected area is right up against a section boundary or some kind of pavement, such as a road, then there is no chance to filter stormwater runoff from the human-dominated areas.

Wetlands and small ponds with lawn right to their margins are other examples of bad planning. Lawns are usually managed using fertilisers, pesticides, and herbicides, and without a buffer between the lawn and the water body, these chemicals can drain right into the water.

How ‘natural’ are the natural areas? The protected area should not be heavily infested with invasive exotics, such as wilding pines, and or dominated by exotic/ornamental vegetation such as old fruit trees. A conscientious developer will implement some restoration plan to infuse a greater diversity of native plants and remove invasive exotic vegetation, with a long-term strategy to prevent reinvasion.

Further, a subdivision with protected natural areas should have a management/educational programme for the whole community that addresses the boundaries and possible impacts between natural and human-dominated areas (see *Post-construction Section 2.5*). The health of these natural

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<sup>53</sup> New Zealand Arboricultural Association Inc. <https://www.nzarb.org.nz/>

areas is intricately tied to the behaviours of nearby residents. The covenants, codes, and restrictions (CCRs – see example in Appendix B) should explicitly address the long-term management of common spaces.

*Invasive exotic plants and animals:* We note here that the presence of invasive exotic plants and animals should have been identified during the design phase with flora and fauna surveys. During the construction phase, many of the invasive exotic plants can be removed during construction. Such plants should be marked for removal by machinery or, in certain situations, chemical means. Plus, a pest trapping programme could be begun at this stage to control for possums, stoats, and other pests (see expelling invasive exotics in the post-construction section of the course manual for definitions, control strategies, and types of invasive exotic animals and plants).

#### 2.4.6 Use low impact development techniques for stormwater treatment<sup>54</sup>

In subdivisions, a good deal of impervious surface within a neighborhood (e.g. buildings, driveways, and pavement) prevents the water from soaking into the ground. Without adequate stormwater retention systems, surface water can accumulate and not only flood nearby areas but can carry added nutrients and chemicals to nearby wetlands and waterbodies. During rainfall, the first couple of centimetres of water runoff contain a majority of the human-made pollutants. Think about the roads in your neighbourhoods with oils and other chemicals deposited on the surface; rain washes these chemicals off the road and this initial flush of water enters nearby streams, ponds, and wetlands. Thus, runoff needs to be slowed down and retained within a development to prevent volumes of water contaminating natural areas and/or flooding other properties. Conventional stormwater systems, such as curbs and culverts, channel water directly into nearby streams, rivers, or even the ocean. A better solution is to use low impact development (LID) techniques that allow water to percolate into the ground where it falls and not allow any water to flow off site. LID techniques are preferred because they can have a positive benefit for both biodiversity and water quantity/quality issues. These include<sup>55</sup>:

- *Groundwater recharge and baseflow in streams:* Many stream systems depend on groundwater seepage to maintain baseflow between storm events. LID is designed to better match pre-existing hydrological conditions on the site, which means more water is routed back into the soils and less is running off on the surface. On a large scale, near the coast, this same concept could apply to things like saltwater intrusion where the routing of stormwater to tide instead of allowing it to infiltrate reduces the freshwater table, allowing saltwater to move further inland.
- *Soil fertility:* Most LID practices promote conservation of existing natural features and minimum soil disturbance. In addition to the direct benefits of habitat provided by whatever natural feature remains, the topsoil and litter layers remain intact. If a future homeowner wanted to landscape the area, they would have far more conducive soils for planting than if the site had been cleared, soils disturbed, and low-fertility soils used to infill the site. What's the ecological benefit? When the natural fertility is left in the soil, the homeowner is less likely to fertilise or water the plants.
- *Soil fauna:* Linked to above – minimising disturbance preserves the plants and trees above ground, but it also maintains a very diverse and dynamic soil system below ground.
- *Soil stormwater treatment:* By promoting spatially distributed infiltration features, stormwater will be in contact with a larger total soil surface area than in a conventional retention pond. In addition, shallower depths in a rain garden or bioretention area mean there is less head on the water infiltrating; therefore the rate of infiltration is less. Both soil surface area and contact time are factors that will typically improve removal of unwanted nutrients or contaminants from the water.

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<sup>54</sup>Adapted from Ignatieva et al. 2008.

<sup>55</sup> Personal communication, Dr Mark Clark, University of Florida

- *Soil moisture mosaic*: By creating multiple stormwater management areas throughout the subdivision, the landscape becomes more diverse with respect to soil moisture. This creates an opportunity to increase overall vegetative diversity by planting a wider range of native species suited to different parts of the moisture gradient.
- *Enhanced stormwater basins*: With LID, stormwater basins can be designed with native vegetation and sculpted with shallow dabbling areas to benefit local wildlife. One of the most dramatic effects of development is homogenisation of the landscape toward turf and a narrow range of landscaping plant species. This in turn may limit recruitment of native species in a watershed. Because stormwater ponds often have outlets to public waterbodies, increasing the diversity of the seed source in the stormwater basin could increase diversity downstream and at least maintain a viable seed stock in the catchment.

### Stormwater treatment trains

A stormwater treatment train is a series of components or devices linked together from the top to bottom of an urban catchment. It lengthens, slows, and filters the passage of water moving through the urban catchment from roof to river, sea or groundwater. The principle is bioretention and infiltration where biological, chemical and physical properties of plants and substrates act to filter and improve the quality and quantity of water across a landscape. This can start from permeable pavement and green roofs and end with retention or detention ponds. A variety of LID treatment trains can be implemented to prevent water flowing off site. However, a more distributed stormwater treatment system is preferred as to allow water to percolate where it falls (reasons are mentioned above). Thus, stormwater ponds should be constructed as a last resort and a more distributed infiltration system should be constructed (e.g. rain gardens on each lot - these rain gardens act like mini-detention ponds). In some cases, if designed correctly, local wetlands and natural depressions can be used as water catchment areas that receive stormwater. We stress though that if a natural wetland or existing water body is used as the end of a stormwater treatment train, you must be extra careful to implement a design and management system that minimises the influx of nutrients and pollutants. The flow of water has to be slowed down beforehand and somewhat filtered by other devices (e.g. swales). If not, the natural wetland could fill up with sediment fairly quickly, become polluted, or become overrun with exotics. The end result would be a loss of native plant and animal species within the wetland.

Below, we list some possible LID features and discuss how they can improve biodiversity and address water quantity and quality issues:

- Swales and filter strips
- Retention and detention ponds
- Permeable paved surfaces
- Raingardens
- Green roofs

#### I. Swales and filter strips

A swale or filter strip is an ephemeral watercourse for overland flow of stormwater (see examples in Figures 12, 13, and 14). It is a shallow, linear depression in the ground that is designed to collect and move stormwater runoff along gentle slopes (Dunnett & Clayden 2007, p. 106)<sup>56</sup>. Some subsurface filtration and evaporation of accumulated water occurs but the vegetated surface provides for filtration and slowing of stormwater. This may be a thick (50–100 mm) mown turf, herbaceous plantings or taller vegetation, but in the latter case the cross-sectional capacity will be slightly larger to accommodate water flows as well as the vegetation. The main function of a swale is to allow settling and filtering of coarse sediments and contaminants from stormwater, and transport residual water to an infiltration or detention area such as a rain garden, infiltration basin, wetland or pond.

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<sup>56</sup> Dunnett N, Clayden A 2007. Rain gardens. Managing water sustainability in the garden and designed landscape. Timber Press.



**Figure 12** *Carex* cultivars cover swale surface at Wharewaka, Taupo. Note stone detention dams used to reduce flow strength. Photo: Robyn Simcock

Where swales are designed to infiltrate water they will usually be underdrained. Increasingly, roads provide the space for infiltration and filter strips. When water (runoff) passes through vegetation, contaminants can be removed by filtration, infiltration, absorption or biodegradation<sup>57</sup>. The type of swale, its structure and composition, is dependent on the slope, ground water level and soil physical properties. Figure 12 demonstrates the use of devices to break the flow on steeper slopes.

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<sup>57</sup>For further details refer to the swale design information in 'Stormwater treatment devices' (Chapter 9) Auckland Regional Council ([www.arc.govt.nz/arc/index](http://www.arc.govt.nz/arc/index)); Christchurch City Council [www.nzwwa.org.nz/section3.pdf](http://www.nzwwa.org.nz/section3.pdf) (Selection and Design of Stormwater devices) and from 'On-Site Stormwater Management Guideline' ([www.nzwerf.org.nz/publications/sw602/sw602.html](http://www.nzwerf.org.nz/publications/sw602/sw602.html))



**Figure 13** *Vegetated swale behind the building previously tenanted by Waitakere City Council in Henderson. Photo: Marjorie van Roon*



**Figure 14** *(Left) Swale, Auckland Netball Centre carpark with prostrate coprosma and treepits - boulders protect overflow grate that discharges to pond. Photo: Robyn Simcock.*



*(Right) Bioretention swale, Landcare Research, Auckland, with Carex against the building and Libertia, Scleranthus biflorus, Selliera radicans, Pratia, and Acaena. Note the lack of curb allows water to run off from carpark. Photo: Robyn Simcock*

*Primary native plants for vegetated swales:* Using native plants improves both the physical environment and biodiversity. Different native plant species will thrive under permanently wet swales and swales that are dry during the summer. Depending on the size of the swale, trees can be planted on the slopes, shrubs and tussocks in the swale base, and for mown swales, a variety of short sward species can be used. Lists of suitable plants are in the Landcare Research's manual *How to put nature into our neighbourhoods* . . . Detailed lists for riparian zones can be generated from the Christchurch City Council streamside planting guide (see [www.ccc.govt.nz/parks/theenvironment/streamside.asp](http://www.ccc.govt.nz/parks/theenvironment/streamside.asp)).

## II. Retention and detention ponds

*Retention ponds* are characterised by a permanent pool of water that mixes incoming stormwater with previously collected water (Figure 15). Discharge is through seepage into soil and evaporation. Detention ponds serve as excess-water catchments that dry up between storms. If such ponds are needed, a civil engineer will calculate soil permeability, amount of impervious and pervious surface area, and recommend the number and depth of stormwater ponds to be constructed. These ponds serve as a place to temporarily hold water that can evaporate over time or be allowed to percolate into the soil on site. As the theory goes, contaminants in the water bind to the soil particles and help clean underground water flow so that if and when it does encounter surface water (e.g. a stream), it is not polluted. However, as mentioned above for the purposes of water quality and biodiversity, a more distributed stormwater treatment system is preferred as it allows for better filtration of water (more soil surface area in contact with water), and it promotes a diverse soil mosaic (supporting a variety of plants throughout the site).

One can create wildlife habitat along both types of ponds, but in particular, retention ponds that contain water all year round can attract wading birds foraging for fish and other aquatic wildlife found in the water. The shoreline edges of retention ponds should include open areas and areas with native tall and shrubby vegetation. The area within the first few metres of a pond, i.e. the littoral zone, should contain a mixture of open water, floating vegetation, and both short and tall emergent vegetation. A mixture of vegetation structures in both zones will attract a wide variety of wading birds. In order to have a food rich littoral zone though, the edges of a stormwater pond must not be dug too deep. Instead, a gently graded shoreline will provide shallows for dabbling and foraging birds. A diversity of species will favour ponds with just a small amount of the shoreline dominated by lawn; the rest could be a mixture of trees, shrubs, and other vegetation occurring both in the water and around the shore. Detention ponds that are cut deep (with no littoral shelf at the edge of the pond), completely surrounded with cement or grass, or with no native vegetation around or in the water, you can assume will be little used by wildlife.

When designed properly, detention ponds can function as community fields or parks for residents. This makes it more likely that residents will use these fields for outdoor activities, and retention ponds can be an outdoor activity amenity for a community.

For further information on construction of ponds refer to the detention pond design details in manuals prepared by Auckland Regional Council and Christchurch City Council<sup>58</sup>. Again, native plants can be used for stormwater ponds. Certain species are best for the wet margins and drained slopes; for a list of species, refer to Landcare Research's manual *How to put nature into our neighbourhoods . . .*

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<sup>58</sup> For further details refer to the swale design information in 'Stormwater treatment devices' (Chapter 9); Auckland Regional Council ([www.arc.govt.nz/arc/index](http://www.arc.govt.nz/arc/index)), and guidelines from Christchurch City Council – 'Selection and design of stormwater devices' ([www.nzwwa.org.nz/section3.pdf](http://www.nzwwa.org.nz/section3.pdf)) and 'On-site stormwater management guideline' ([www.nzwerf.org.nz/publications/sw602/sw602.html](http://www.nzwerf.org.nz/publications/sw602/sw602.html))



**Figure 15** A retention pond for various neighbourhoods in Christchurch; note use of native plants around shoreline. Photo: Mark Hostetler

### III. Permeable paved surfaces

One of the most effective means of ameliorating rapid stormwater runoff is to minimise hard surfaces and to use permeable materials when needed for hard wearing or vehicle standing. Several impervious products are available that allow water to percolate into the ground (see Figure 16). For construction materials and designs refer to existing manuals<sup>12</sup>.



**Figure 16** Example of permeable paving, Seattle. Photo: Maria Ignatieva

Even here, an opportunity exists to increase the diversity of native plants and animals in the area by using native plants in association with the permeable pavement. Suitable native plant species for pavements of various types and wastelands (untended land and early-successional urban vegetation) can be found Landcare Research's manual *How to put nature into our neighbourhoods*. . . .

#### IV. Raingardens

Raingardens filter, detain and evaporate water (see examples, Figures 17, 18, 19). They are essentially a deep, well-drained, porous bed in which water usually ponds to between 100 and 300 mm depth for several and up to 36 hours after rainfall. The bed is generally vegetated with dense low plants. The excavated bed is lined with geotextile then covered in media that are increasingly coarse with depth. They are placed in low-lying areas with specific layers of soil, sand and/or mulch to filter stormwater naturally. Raingardens are usually under-drained and always have an overflow or bypass through which the majority of runoff from large storms passes. During dry periods, the soil absorbs and stores rainwater, which allows plants to grow. With the appropriate species for the area, they should require little or no irrigation. Once established they are self-watering, self-fertilising gardens, and particularly suitable for supporting native plants in urban environments. Raingarden design details are found in various local government manuals<sup>59</sup>.



**Figure 17** Raingarden with boardwalk, Landcare Research, Auckland. *Muehlenbeckia astonii*, *Hebe speciosa* and *Libertia peregrinans* are the prominent species. Photo: Robyn Simcock

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<sup>59</sup>'Stormwater treatment devices' (Chapters 4 and 9) Auckland Regional Council – [www.arc.govt.nz/arc/index](http://www.arc.govt.nz/arc/index), and from Christchurch City Council – 'Selection and design of stormwater devices' – [www.nzwwa.org.nz/section3.pdf](http://www.nzwwa.org.nz/section3.pdf) and 'On-site stormwater management guideline' – [www.nzwerf.org.nz/publications/sw602/sw602.html](http://www.nzwerf.org.nz/publications/sw602/sw602.html)



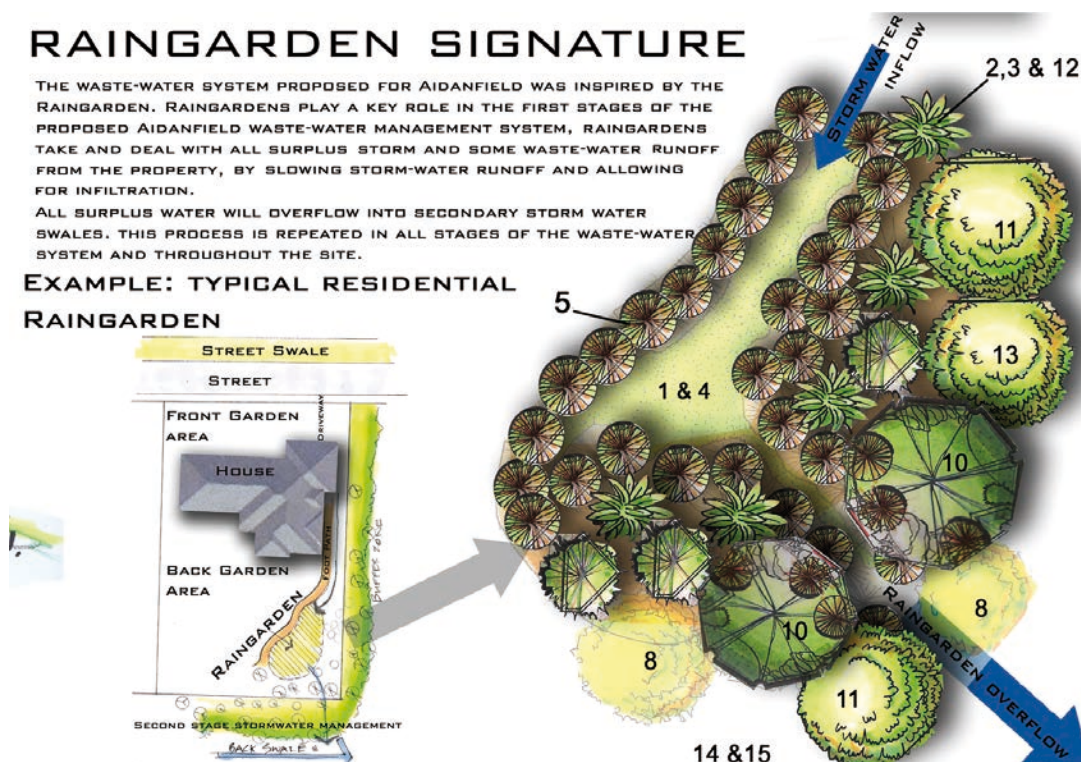
**Figure 18** Hunt Street, Hamilton, raingarden associated with traffic calming (Megan Wraight, Wraight and Associates Landscape Architects). Photo: Robyn Simcock

## RAINGARDEN SIGNATURE

THE WASTE-WATER SYSTEM PROPOSED FOR AIDANFIELD WAS INSPIRED BY THE RAINGARDEN. RAINGARDENS PLAY A KEY ROLE IN THE FIRST STAGES OF THE PROPOSED AIDANFIELD WASTE-WATER MANAGEMENT SYSTEM, RAINGARDENS TAKE AND DEAL WITH ALL SURPLUS STORM AND SOME WASTE-WATER RUNOFF FROM THE PROPERTY, BY SLOWING STORM-WATER RUNOFF AND ALLOWING FOR INFILTRATION.

ALL SURPLUS WATER WILL OVERFLOW INTO SECONDARY STORM WATER SWALES. THIS PROCESS IS REPEATED IN ALL STAGES OF THE WASTE-WATER SYSTEM AND THROUGHOUT THE SITE.

### EXAMPLE: TYPICAL RESIDENTIAL RAINGARDEN

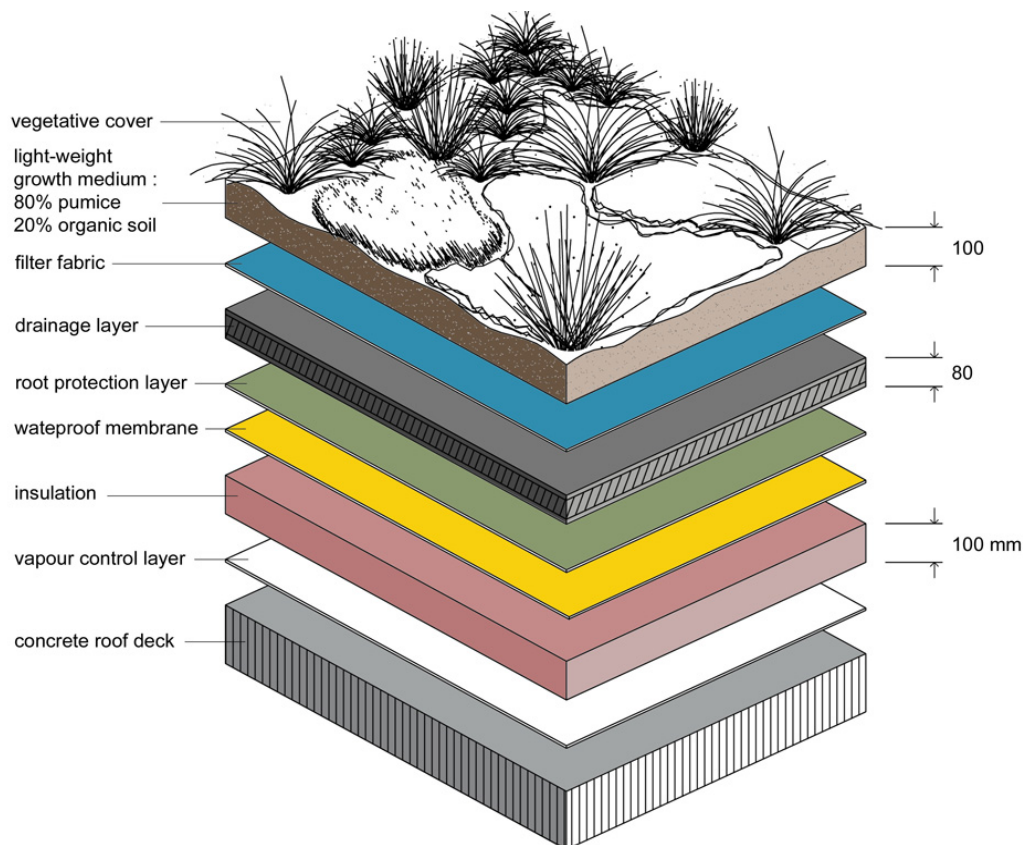


**Figure 19** Raingarden for residential property in Aidanfield, Christchurch. Design: Frazer Baggeley, 2005

*Use native plants in raingardens:* The opportunity exists to use primarily native plants in raingardens and this will improve biodiversity across a site. Some species do well in high-rainfall versus low-rainfall areas. Species lists can be found in Landcare Research’s manual *How to put nature into our neighbourhoods*. . .

## V. Green roofs

A green roof is a roof partially or fully covered by plants. Modern green roofs can be categorised as extensive, semi-intensive, or intensive. The opportunity to increase biodiversity is the use of native plants on the roofs of buildings. Plant species list for green roofs can be found in Landcare Research's manual *How to put nature into our neighbourhoods...*



STRUCTURE : EXTENSIVE GREEN ROOF

**Figure 20** *Extensive green roof structure. Design: Lucas Adam, 2007*

Extensive (thin) green roofs feature drought-tolerant plants grown in a thin layer (50–150 mm) of lightweight soil (Figure 20). They are not designed to be accessible, other than for occasional weeding.

Semi-extensive (thick) green roofs, also known as semi-intensive roofs, have deeper soil (150–300 mm) and can support a greater variety of plants (Figure 21). However, their depth makes them heavy and they require a relatively strong structure to support them.



**Figure 21** Waitakere Civic Centre, semi-extensive green roof at about 16 months old. Photo: Robyn Simcock

**Intensive (partial)-green roofs** consist of plants grown in deep soils, allowing the growth of shrubs and even small trees. Usually grown in irrigated containers, they require more maintenance than extensive and semi-extensive roofs. They are usually designed to provide an accessible amenity space. Because they require considerable structural support they are much more expensive than extensive roofs, and impractical in most domestic situations.

Green roofs offer a range of benefits not provided by conventional roofs, such as:

- Stormwater reduction, retention and filtration
- Cost savings in heating and air conditioning due to the insulating effect of the growing medium and plants
- Protection of the roof from UV damage
- Habitat for insects, plants, birds, and even lizards
- Moderation of the urban heat island effect

If you are not sure about how much of a roof to allocate as green, demonstration mini-green roofs allows you to trial a range of local, drought-tolerant plant species. The pitched roof will support a semi-extensive green roof, with an assemblage of plants from grassland and dry rocky environments. The 'flat' extensive green roof will support a selection of coastal and other dryland plants.

#### 2.4.7 Install efficient irrigation systems

For areas that must be watered, an efficient irrigation system, such as drip or micro-irrigation, should be installed (see [www.floridaswater.com/](http://www.floridaswater.com/)). About 77% of New Zealand's water supply is used for irrigation (primarily for agricultural purposes). Even within homes and sections, 25% of the water use is for the garden and lawn (more tips and facts can be found at [www.sustainableliving.org.nz/](http://www.sustainableliving.org.nz/)). The most efficient system of all is one that combines soil moisture sensors for turf irrigation with a micro-irrigation system (see fact sheet <http://edis.ifas.ufl.edu/AE144>). The sensor tells the automated irrigation system to turn on only when the soil is too dry. This way, the section is only watered when the soil is lacking the moisture required to keep plants healthy. As another strategy, rain barrels or tanks can collect water off roofs and be hooked up for irrigation of landscaped areas. The main benefit for biodiversity is that an efficient irrigation system will use less local groundwater and produce less runoff (from overwatering). Therefore, local wetlands and water bodies will not dry up as much and will not be inundated with pollutants running off lawns.

Although irrigation systems are usually designed for an individual property, a central watering system for the whole neighborhood would be a truly efficient system. Maintained by a knowledgeable landscaping company, a central system can reduce the amount of management error by individual homeowners. If the developer has installed an irrigation system for each section, be sure the homeowners are trained about how to manage these systems properly.

#### **2.4.8 Reduce, reuse, or recycle materials on site**

Remember that conserving biodiversity extends beyond the boundaries of a property. Nearby habitat is affected by many actions that occur on a development site. It is easy to see the benefits of directly conserving natural habitat on your development site. Yet, the efficient use of building resources can also preserve habitat in distant locations where the point of resource harvesting takes place. It is important to remember that somewhere around the world, natural habitat is being degraded to create our building products and power our homes and cars. By limiting the amount of virgin resources that need to be extracted to build your development, you can save energy, water, and land in someone else's valuable natural areas.

#### **2.4.9 Use trained contractors and subcontractors**

We cannot stress this enough, it is crucial to have trained and motivated contractors and subcontractors. Even if on paper you have the best conservation design, it is dependent on the contractors, landscapers, and subcontractors to properly implement the plan<sup>60</sup>. Often, these groups of professionals are not brought in during the design phase and are not fully engaged or understand the conservation priorities of the project. Without trained or fully engaged contractors or landscapers, many things can happen during the construction phase that could impact the viability of onsite or nearby natural habitat. In many cases, local site conditions may not correspond well with the original intent, and adaptations to the original plan are warranted. Thus, construction site managers need to be fully engaged and aware of practices that influence biodiversity when plans have to be modified. In particular, a well-informed construction site manager is critical. For example, a construction manager that has read and understood the principles and suggestions in this manual can more readily anticipate construction practices or accidents that might compromise the ability of the development to promote biodiversity.

**We strongly recommend** that all tradesmen and built environment professionals associated with the development project take an educational course that addresses biodiversity and environmental issues. Both private and/or public institutions can administer such courses. This course is one such example. At a minimum, local council policies should require that built environment professionals associated with green development projects take such courses.

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<sup>60</sup> Hostetler ME, Jones P, Dukes M, Knowles H, Acomb G, Clark M 2008. With one stroke of the pen: How can extension professionals involve developers & policymakers in creating sustainable communities? *Journal of Extension* 46/1.

## 2.5 Phase 3: Post-construction



*Lincoln township, New Zealand. Photo: Mark Hostetler*

The focus on this section is long-term management of the homes, sections, conserved open space, and neighbourhoods. It's all about the people in a community! After the developer has sold the lots, how can the developer ensure that the built areas and perhaps nearby conserved or restored natural areas are maintained in such a way as to not only minimise impacts on biodiversity but to improve and sustain biodiversity? Below we discuss the issues surrounding the management of sections, homes, and neighbourhoods and how they interface with the management of conserved areas. A developer can implement several programmes and actions that will help to improve biodiversity over the long term, and we list a few of those options. In addition, we touch on the importance of monitoring your site and discuss the various management issues and solutions for keeping a conservation area healthy, including removing invasive exotics. Although the focus is on subdividing a property, many of the management issues discussed below are relevant to rural landowners attempting to restore or conserve portions of their property and to homeowners attempting to retrofit their communities.

Environmentally sensitive development will have some preserved, created, and/or restored natural communities. However, a long-term management plan is necessary to maintain the biological integrity of conserved or restored areas. This plan is an essential component of the post-construction phase of a development. Key features of this management plan are:

1. Implementing a local environmental education programme for homeowners
2. Minimising human impacts on conserved areas
3. Resolving human–wildlife conflicts
4. Expelling invasive exotics
5. Securing permanent funding for a management programme
6. Monitoring the success of your efforts
7. Producing and distributing a homeowner handout on maintaining biodiverse yards and neighbourhoods

### 2.5.1 Implementing a local environmental education programme for homeowners

Studies have indicated that homeowners who live in conservation subdivisions do not understand the function of conserved open space and are not aware of appropriate management practices to maintain biodiversity. One study in Florida found that residents of a conservation subdivision did not differ or scored lower on several questions about environmental knowledge, attitudes, and behaviours than residents of 'conventional' communities<sup>61</sup>. In another study, new homebuyers of conservation subdivisions and conventional communities were little different in terms of environmental knowledge, attitudes, and behaviour – and overall measures were quite low for all respondents, regardless of community type<sup>62</sup>. Thus, conservation subdivision communities may not be attracting or encouraging environmentally sensitive residents, and in the absence of an environmental education programme to engage residents, a community may resort to environmentally insensitive behaviours<sup>63</sup> and not retain the long-term ability to manage open space habitat of good quality.

Once the homes are built and people move into these conservation subdivisions, homeowner understanding and buy-in are essential if the subdivision is to function as originally intended. Although it was the developer who implemented the design, it is up to the community residents to manage and maintain defining features. Furthermore, decisions made by homeowners in maintaining their own homes and sections can have serious consequences for nearby conserved open spaces.

Design and management strategies that benefit biodiversity will not work unless there is a long-term commitment by homeowners. As an example, consider the effect when a homeowner adds new plants to her/his garden and her/his choice includes some weed plants. That choice could have an impact on natural areas that a developer set aside during site development. The invasive plants could spread into those natural areas and have a negative impact on the habitat. Property owners need to know which plants are considered invasive exotics and avoid planting them in their gardens. They also need to know how to remove any invasives that might be currently part of their gardens. In particular, research has shown that the initial landscaping of a section, e.g., whether it includes native plants, helps engage residents and promotes an interest in managing for biodiversity in their neighborhoods. For example, a community in Illinois, Prairie Crossings, successfully raised the profile on the importance of maintaining native prairie grassland through a combination of printed materials, a web site, several workshops associated with the homeowner association, and most importantly, requiring that every yard contain at least 20% of prairie plantings<sup>64</sup>.

As a design professional or developer, it is important to establish an educational programme before homeowners move into a neighbourhood. Neighbourhoods turn over, houses are sold all the time, experienced owners leave, and new owners arrive, unfamiliar with the community 'green culture.' All residents must be on board in terms of understanding the goals of the community and actions that help conserve natural resources. One way to get the word out is for the developer to set up an educational programme that consists of a brochure, a website, and kiosks (for details, see Appendix B). These three elements help inform residents in the following ways:

- **Interpretive kiosks:** Highly visible interpretive kiosks/signs are placed in public areas where people traffic is high or on a trail system. Each of the signs contains informative displays that discuss a particular topic, such as water, energy, or wildlife. Kiosks should be dynamic, with different informative panels being inserted throughout the year. These kiosks are not only informative, but they provide a place for neighbours to interact and can serve as a catalyst for people to obtain more information by directing them to the website (see Figure 22).

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<sup>61</sup> Youngentob K, Hostetler ME 2005. Is a new urban development model building greener communities? *Environment and Behavior* 37: 731–759.

<sup>62</sup> Noiseux K, Hostetler ME 2007. Are new homeowners in green developments ready to live green? *Journal of Planning Education and research*. *In review*.

<sup>63</sup> DeLorme D, Hagen S, Stout I 2003. Consumers' perspectives on water issues: directions for educational campaigns. *Journal of Environmental Education* 34(2): 28–35.

<sup>64</sup> Thompson, R H. 2004. Overcoming barriers to ecologically sensitive land management - Conservation subdivisions, green developments, and the development of a land ethic. *Journal of Planning Education and Research* 24(2): 141-153.

- **Website:** Because the kiosks/signs can give only limited information, an associated website is constructed that gives more detailed environmental information and management strategies pertinent to a community.
- **Brochure:** A brochure is given to each new homeowner. This introducing brochure highlights local natural resource features and issues and invites homeowners to view the kiosks in their neighbourhood and visit the website.



**Figure 22** Educational kiosk installed in Harmony, Florida Photo: Jennifer Vann

How successful is the above programme? A recent study compared residents of a community (Harmony) that had an environmental educational programme (website, educational kiosks, and brochure) with residents of a community lacking such a programme; results demonstrated that residents of Harmony had improved awareness and confidence to implement neighbourhood natural resource conservation practices<sup>65</sup>.

Proactive developers can also make links with local agencies and organisations that are interested in sustainable development. Often a variety of resources and assistance are available to local residents if only they knew about them. The educational programme prepared by the developer should contain information about local environmental programmes and contacts.

**Policymakers must provide incentives for developers to implement educational programmes.**

Without which, many developers may not take the first step. Implementing such an educational programme is about building a sense of place, attachment, and pride, where an engaged group of people will care for their natural environment. At a minimum, a developer should have kiosks along the footpath. Environmental information should be specific to the community and natural resource issues, not just a general list of 'good' practices – for example, the website should not simply say it's good to recycle, but should list nearby places where residents can recycle materials. For large master-planned communities, it is also useful to have a full-time conservation manager who works for the neighbourhood. This manager can serve as a local source for information and help implement newsletters, local conservation committees, and environmental activities such as bird walks and clean-

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<sup>65</sup> Hostetler ME, Swiman E, Prizzia A, Noiseux K 2008. Reaching residents of green communities: Evaluation of a unique environmental education program. *Applied Environmental Education and Communication*. *In review*.

ups. For a living example of a community that has both an environmental education package and a conservation manager, visit the town of Harmony at [www.harmonyfl.com/lih/index.htm](http://www.harmonyfl.com/lih/index.htm).

### 2.5.2 Minimising human impacts on conserved areas

Daily activities and decisions by homeowners can have serious and cumulative impacts on neighboring reserves. For example, pets (particularly cats) that are off their leash and roaming in conserved areas could become significant predators on a wide variety of amphibian, reptile and bird species. Feral cat colonies can become established near suburbs depending on the behaviours of local residents. Cats from these colonies are known to prey on New Zealand birds and skinks; however, in some urban situations, cats have an intermediate beneficial effect of reducing mammalian predators such as mice, rats, and stoats. Even the way homeowners manage their own sections can impact conserved areas. For example, if water comes from local groundwater, a neighbourhood consuming too much water can dry up nearby wetlands and affect the habitat for many wildlife species (e.g. nesting and/or roosting waterbirds). Plus, due to runoff, fertilisers and pesticides can enter local streams and waterbodies and wetlands; such influxes of additional nutrients and toxins can change vegetation in conserved open spaces to a point where it is not conducive to wildlife diversity.

Just the presence of humans walking near or through conserved areas can negatively affect wildlife. The frequent presence of humans within an area has been shown to diminish the number of breeding bird territories and number of nests<sup>66</sup>. Thus, local residents need to understand the importance of staying on designated trails and not walking through or using bikes and other vehicles to traverse conserved areas. Developers can use a combination of educational trail signage (see section 2.5.1 above) and a written legal document (e.g. Community Codes and Restrictions [CCR] document that is associated with the deed for the built lot, see Appendix A), which addresses the management of conserved areas and responsibilities of residents.

#### Box 8 Case example: Okareka walkway, Rotorua

Through a collaborative effort between a local landowner, Environment Bay of Plenty, Rotorua District Council, Fish and Game, and a local Okareka Landcare Group, a walkway near Lake Okareka was built to give access to residents. In conjunction with the walkway, local residents and environmental groups have been restoring areas near the lake edge to improve wildlife habitat and to increase native plant diversity. Previously, many areas near the lake had pasture right up to the edge of the lake, but fences have been installed to keep out cattle and native vegetation has been planted near the lake edges to restore the habitat. In the past, many people were using the area for walks and were traversing across habitats and there was concern about how these areas were degrading. The path and boardwalk itself was designed to keep people on the path and in some areas, the path veers away from the edge of the lake as not to disturb waterbirds. The Okareka Landcare group and even the nearby residential community, under the Lake Okareka ratepayers & Residents Association ([www.lakeokareka.org/](http://www.lakeokareka.org/)) have taken a vested interest in the care and management of the lake and the lake edge. Many of the group's activities involve minimising local impacts and restoring biodiversity to the area, including native planting days and efforts to control possums and rats. The new plantings around the shoreline have buffered the lake from upland pollution and has created habitat for a variety of birds, including pied stilts, shovelers, teals, coots, and dabchicks.



Okareka walkway Photo: Sandra Goodwin

<sup>66</sup> Lenth BA, Knight RL, Gilgert WC 2006. Conservation value of clustered housing developments. Conservation Biology 20: 1445–1456.

### 2.5.3 Resolving human–wildlife conflicts

Human–wildlife interactions, both within and around residential areas, can be a positive experience for the homeowner, with very little detrimental affect towards the animal. Many New Zealanders enjoy viewing wildlife in and around their homes. Nationwide, bird watching is a multi-million-dollar industry with bird feeders a common sight on neighbourhood properties. In New Zealand, much of the state's ecotourism activities centre on people viewing wildlife. Bird watching is a popular activity among New Zealanders and visitors alike.

Nevertheless human–wildlife interactions can be detrimental for both animals and humans. There are numerous examples where people create a situation that directly impacts the well-being of wildlife populations. This can take place accidentally or on purpose. For example, feeding ducks in urban areas can lead to increased nutrients in local ponds causing algal blooms and other water quality issues.

As mentioned previously, pets from residential neighbourhoods can have a very large impact on local wildlife populations. They can affect the survival of a huge number of birds, mammals, reptiles, and amphibians, both native and exotic. For example, unleashed dogs have injured or killed recently fledged kiwi, weka, and pūkeko. Free-roaming house cats have also been known to affect entire local populations of birds and reptiles. Cats do hunt and can catch and kill quite a variety of native animals. So to err on the side of caution, all cats maybe should be kept indoors or be equipped with cat bibs<sup>67</sup> that help prevent cats from catching animals. Recreational activities, in or near residential neighbourhoods, can also impact local wildlife populations. Off-road vehicle use and even casual hiking, dog-walking, or biking in critical wildlife habitat can disrupt normal animal behaviour.

On the other hand, wildlife can adversely affect people within the neighbourhood. The feeding of wildlife (on purpose or by accident) can cause animals to lose their fear of humans thus becoming a nuisance to surrounding neighbourhoods. Possums and large birds (e.g. geese) can quickly become nuisance animals when people regularly feed them in and around subdivisions. Looking for food, geese and ducks can occur at such high densities as to harm local water quality in ponds and streams. Not all feeding of wildlife may be detrimental, such as feeding small song birds with a birdfeeder. People enjoy watching birds up close and feeders are a good way to draw them in for viewing. However, even with birdfeeders, problems can arise. For example, unclean and wet birdfeeders can spread diseases among birds, so people must keep feeders clean. These are but a few examples of potential detrimental human–wildlife interactions and people should carefully explore the potential side-effects of any feeding of wildlife.

Mammals (especially possums, stoats, and ferrets) can easily lose their 'fear' of humans and become a nuisance when homeowners intentionally or inadvertently feed them. For this reason, one should never feed mammals. It is extremely important to educate homeowners about the dangers of feeding these animals.

Ducks and geese can become a problem in small urban ponds. Many people consider unconfined domestic ducks a nuisance. Some breeds can be aggressive toward pets and children, deposit droppings where they are not desired, and cause damage to lawns and gardens by their feeding and nesting activities.

Further, ducks lay many eggs, and uncontrolled duck populations can increase dramatically in a short time. In small, urban ponds, high bird densities contribute to reduced water quality that lessens the aesthetic value and presents a potential public health hazard. On average, an adult duck produces about 1/3 lb [c. 150 g] of manure each day<sup>68</sup>.

Domestic ducks also can transmit diseases to wild waterfowl. All confirmed outbreaks of duck plague in wild ducks have been linked to domestic ducks. Fowl cholera, paratyphoid, avian tuberculosis, and chlamydiosis are other serious diseases that can be transmitted between domestic and wild ducks.

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<sup>67</sup> Calvera M, Thomasa S, Bradleya S, and McCutcheonb H. 2007. Reducing the rate of predation on wildlife by pet cats: The efficacy and practicability of collar-mounted pounce protectors. *Biol. Conservation*. 137 (3): 341-348.

<sup>68</sup> Domestic duck problems in urban areas – [edis.ifas.ufl.edu/UW015](https://edis.ifas.ufl.edu/UW015)

Some domestic ducks breed with wild species, such as mallard ducks breeding with grey ducks (grey ducks are the native species). As a result, the grey duck has been listed as threatened. Interspecies breeding dilutes the natural genes in native wild populations. Resulting hybrids and the altered gene pool are undesirable for the preservation of wild populations.

Above all, homeowners should be educated about the problems that can occur if they feed ducks and geese. The design of small ponds can help prevent many ducks and geese from settling in ponds. The best design is to avoid lawn that runs right up to the edge of the pond. Having high vegetation around the pond (too high for geese to see over) will prevent ducks and geese from exiting the pond onto property to feed. Planting shrubs and tall emergent vegetation near the shore (e.g. tall tussock species) will help prevent ducks and geese from exiting to feed in certain areas. Also, planting high vegetation is reported to prevent geese from landing on the water as they need a line of sight from the shore to water in order to land.

Raising awareness and providing homeowners with techniques to resolve human–wildlife conflicts will help alleviate problems that arise. An on-site, educational programme that uses tools such as educational signage, websites, and/or brochures can have a positive affect on peoples' attitudes, behaviours, and knowledge about wildlife and empower people to resolve wildlife–human conflicts (See Section 2.5.1 for more information on environmental education programmes). In addition, workshops and neighbourhood meetings work well.

#### **2.5.4 Expelling invasive exotics**

Getting rid of invasive exotics actually starts during the design phase when flora and fauna species are identified. During the construction phase, the process of getting rid of many of the identified invasive plants and animals should have begun. However, the threat of reinvasion is high, especially when invasive plants and animals are known to occur in the vicinity. Thus it takes diligence long after completion of the development. Before giving techniques to expel invasive exotics, we first give some background about invasive exotics and why they are such an important factor for biodiversity concerns.

Exotic plants and animals are invading many of New Zealand's landscapes. These species can drastically alter natural environments, often with negative implications for the sustainability of wildlife and plant communities. They also impact crop growth, stock raising, and wildlife populations in urban and agricultural areas. Invasive exotic species can even affect the health of pets through the transmission of diseases!

Two important concepts form the basis of invasive specie ecology. First, an 'exotic' is any organism that is non-native. Non-native organisms exist in areas where they historically did not occur. For example, many exotic plants come from countries outside New Zealand. It has been estimated that over 50% of known plants in the wild are exotic and about 25% of these exotic plants are classified as 'weeds' (i.e. invasive exotic).

Second, 'invasive' species are those that form self-sustaining and expanding populations within areas, displacing native plants and associated wildlife, including endangered species. They can also alter natural processes such as fire and water flow.

Thus, an invasive exotic species comes from somewhere else and is very prolific in the area that they are found. It is important to understand that a few native species can also become 'invasive' in certain situations (e.g., when they are moved beyond their natural range). On the other hand, many exotic species occur in New Zealand without becoming invasive since they do not take over natural communities. For this section, we will only concentrate on invasive exotic species.

#### **How do invasive exotics affect native wildlife?**

Remember from an earlier section that all wildlife need food, water, shelter, and space. These are the four essentials that make up 'functional' wildlife habitat. However, different species have different requirements within these four essentials. An animal will only live in an area if it contains a sufficient amount of structural objects to satisfy its daily activities (e.g. feeding, courtship, hiding from predators).

So how do invasive exotic plants affect wildlife? Simply put, wildlife populations are affected by invasive exotic plants when they alter the essential requirements of food, water, shelter, and space in a shared natural area. Overall, it is a negative effect, but in some cases it might be positive.

Invasive exotic plants impact wildlife habitat in two major ways:

1. They create new habitat to which wildlife species are not adapted. Often, this habitat is a monoculture dominated by the invasive species. Very few native species are found within this new habitat.
2. They alter the ecological processes and disturbance regimes (such as fire regimes) to which many wildlife species are attuned. In NZ, such exotic weeds may increase fire frequency and hardly any native plants are adapted to fire, but many exotic species are and promote it in their flammable leaf compounds (e.g., gorse)

In many situations, an invasive exotic plant spreads into an area and outcompetes the native plants that wildlife species depend on for food or shelter. For example, yellow ginger (*Hedychium flavescens*) quickly colonises and forms dense patches of yellow ginger, replacing all native species.

### **Why are some plants and animals so good at taking over areas?**

Literally 10's of thousands of new plants and animals have been introduced into New Zealand. Most exotic plants have been introduced through urban gardens. Only some of these species become established and are considered 'invasive'. What makes them so successful? There is not one answer to this question. In general, these new species are quite adapted to New Zealand's climate. They can easily grow and reproduce. Plus, they are free from the stresses of the natural predators, parasites, and diseases that kept them in check in their native habitat. Human behaviour and management can also help invasive exotics. For example, land clearing, home building, and even the use of fertilisers can favour invasive species.

Below, we give background and discuss solutions to controlling invasive exotics::

- Weeds
- Pest mammals
- Invasive insects

### **Weeds**

To learn more about New Zealand invasive exotic plants (weeds), visit the WEEDBUSTERS Website ([www.weedbusters.org.nz](http://www.weedbusters.org.nz)). The below information is excerpted and adapted from that site.

#### **I. Why worry about weeds?**

There are now more introduced plant species growing wild in New Zealand than native plant species. Introduced plant species continue to naturalise at an alarming rate.

- Around Auckland alone there are four garden escapes every year, adding to the more than 300 seriously invasive weeds managed by the Department of Conservation.
- Only 7 species of invasive weeds have been successfully eradicated from New Zealand.
- Invasive weeds are one of the main threats to the survival of 61 threatened native vascular plant species; and impact on another 16 species.
- Weeds threaten the long-term survival of some native animals by changing or destroying their habitat, reducing the availability of food or breeding sites, or influencing the way native and introduced animals behave.
- Weeds are a risk to nearly 600,000 hectares of protected natural areas. Freshwater, wetlands, coastal habitats, lowland forest, shrubland and native grasslands are all vulnerable.
- Weeds cost farmers, growers and foresters tens of millions of dollars every year in herbicides and in lost production.
- Water weeds in hydro lakes hinder electricity generation.

## II. How are weeds introduced?

- Over 75% of the weeds were originally deliberately introduced to New Zealand as garden plants. Many of the 'world's worst weeds' are not yet present in New Zealand.
- New weed seeds come into New Zealand on imported fresh fruit, used cars, used car tyres, boots, camping equipment, and in soil on and around containers.
- Humans = weed problems; and this is an international issue. People bring in new plants that escape; rubbish is dumped in bush reserves; and the expansion of coastal subdivisions and lifestyle blocks exacerbates the spread of pests.
- We have even introduced species originally to serve a special function only to find they soon caused more problems than benefits. For example, old man's beard (*Clematis vitalba*) (Figure 23) was originally from SW Asia and Europe and is a deciduous, climbing vine that is known to take over vast areas.



**Figure 23** Old man's beard (*Clematis vitalba*) Source: Landcare Research

## III. What do weeds cost us?

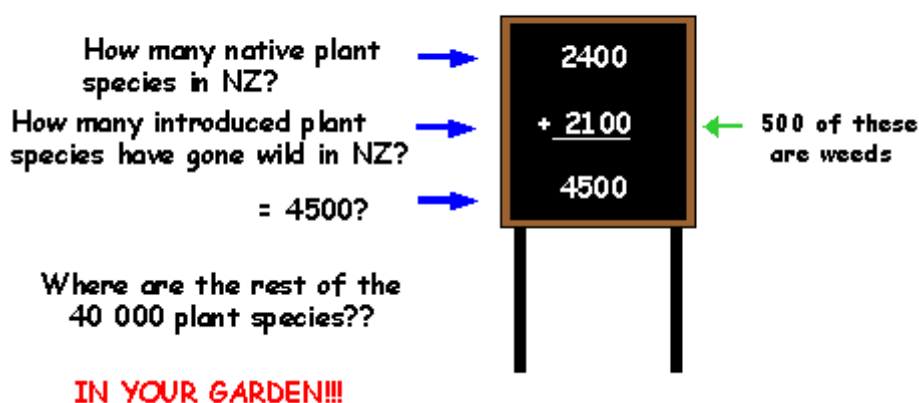
- 10% of the Department of Conservation's managed land is under sustained weed management, and hundreds of thousands of hectares are threatened by weeds.
- Regional, city and district councils spend hundreds of thousands of dollars a year controlling weeds on reserves, parks and other natural areas.
- Weeds are the main threat to the existence of 61 native animal and plant species.
- If left uncontrolled, pest problems expand exponentially. It costs \$3 per hectare per year to control young wilding pines compared to \$1,500 for 25-year-old trees.

#### IV. The importance of your garden<sup>69</sup>

Some 40,000 plants are planted in gardens and parks around New Zealand or are being used in agriculture, horticulture or forestry (Figure 24). More than 70% of New Zealand's environmental weeds were plants that escaped from gardens (they began reproducing by themselves and spread usually by seeds or by people dumping garden rubbish)! Mexican daisy (*Erigeron karvinskianus*) is an example of a pretty flower that has escaped from home gardens into natural systems. Each year, another 12 species of these introduced plants escape and naturalise (go wild) and some will become weeds.

In New Zealand there are 500 plant species that are weeds – they are controlled by farmers, forestry, regional councils or the Department of Conservation. We have more than 276 environmental weeds, these are the weeds that invade native vegetation and harm our unique biodiversity. The list of weeds is growing and weeds are still spreading around New Zealand! Since European settlers came, 144 new plant species have been arriving each year (on average). That is the same as one new plant species every 2–3 days!!

#### There are about 40 000 plant species in NZ



**Figure 24** Numbers of introduced plants in New Zealand Source: Landcare Research  
[www.landcareresearch.co.nz/education/weeds/weedinfoa.asp](http://www.landcareresearch.co.nz/education/weeds/weedinfoa.asp)

#### V. How are pest plants or weeds designated and regulated?

The National Pest Plant Accord (NPPA) is a cooperative agreement between the Nursery and Garden Industry Association, regional councils and government departments with biosecurity responsibilities. All plants on the NPPA are unwanted organisms under the Biosecurity Act 1993. These plants cannot be sold, propagated or distributed in New Zealand. This Act was passed to prevent further spread or importation of invasive exotic plants. The Act restricts the possession, transport, or sale of certain plants that cause injury to public health or are known to interfere with agroecosystems or native habitat. Several useful resources list these restricted plants:

*Officially recognised lists*

1. Biosecurity New Zealand – [www.biosecurity.govt.nz/pests-diseases/plants/accord.htm](http://www.biosecurity.govt.nz/pests-diseases/plants/accord.htm)
2. Weedbusters – [www.weedbusters.org.nz](http://www.weedbusters.org.nz)
3. Regional Councils

<sup>69</sup> The following is excerpted from the Landcare Research website –  
[www.landcareresearch.co.nz/education/weeds/weedinfoa.asp](http://www.landcareresearch.co.nz/education/weeds/weedinfoa.asp)

## VI. Some common invasive exotic plants on New Zealand private lands<sup>70</sup>



*Gorse Photo: Landcare Research*

Common name:

- *Gorse*

Botanical name:

- *Ulex europaeus*

Comments:

Invades drylands, grasslands, and wetlands, shading out native plants. But can act as forest nursery near native seed sources if the area is kept free of browsers and fire (e.g. Hinewai Reserve on Banks Peninsula).

Common name:

- *Broom*

Botanical name:

- *Cytisus scoparius*

Comments:

Invades unique braided rivers and destroys habitat for waterbirds. Dominates young bushes and scrub, preventing the seedlings of native species from establishing.



*Broom Photo: Landcare Research*



*Heather Photo: Landcare Research*

Common name:

- *Heather*

Botanical name:

- *Calluna vulgaris*

Comments:

Rapidly forms dense stands in low-growing habitats, preventing the establishment of native species.

<sup>70</sup> The below content is excerpted and adapted from weedbusters's website – <http://weedbusters.co.nz>

Common name:

- *Buddleia*

Botanical name:

- *Buddleja davidii*

Comments:

Forms dense stands in wide range of habitats. In riverbeds it can alter water flow, causing silt build-up and flooding. Usurps space for native riverbed plants



*Buddleia* Photo: Landcare Research

## VII. Control of invasive exotic plants

### **Preventative practices:**

Of course the best way to limit the number of invasive exotic plants is to become familiar with a weeds list and avoid planting these types of plants. **However, a main concern is what homeowners will do once they move into the community.** They can unknowingly plant or help propagate invasive exotic plants. Thus, it is critical to establish some environmental education programme that informs residents about invasive exotic species. Information on identification and management can be communicated to residents through signs, brochures, and websites (see Section 2.5.1 above).

Of note is the use of earthwork machinery on construction sites. They should be thoroughly cleaned and checked for invasive plant seeds, particularly if they came from another part of the country. This is how the invasive plant fennel was brought into Dunedin on machinery building the southern motorway.

### **Biological control:**

Biological control is the practice of introducing reproductive populations of foreign insects or diseases that attack invasive exotic plants. Many such agents have are being researched and have been used in New Zealand with varying amounts of success. For example, over the past decade heather beetles (*Lochmaea suturalis*) (Figure 25) have been released to control the noxious weed heather (*Calluna vulgaris*). It has been somewhat of a success when released at low-altitude sites near Rotorua and adjacent to Tongariro National Park.

Caution is used regarding the release of biocontrol agents because they may attack our native species or disrupt the ecological balance of an ecosystem. Many approved biological agents are available to landowners for their use. In New Zealand, landowners should contact their regional council office and speak with the pest control officer about biological control in their area. In fact, many biological controls are widespread and one could gather these agents up in the wild. The trick, of course, is determining which agents are appropriate and how to recognise them. A very useful resource, The Biological Control of Weeds Book, can be found on the Landcare Research website – [www.landcareresearch.co.nz/research/biocons/weeds/book/](http://www.landcareresearch.co.nz/research/biocons/weeds/book/).



**Figure 25** Adult heather beetle (*Lochmaea suturalis*) on heather plant (*Calluna vulgaris*).

**Manual removal:**

Manual removal is time-consuming. However, it is often a major component of effective invasive exotic plant control. Seedlings and small saplings can sometimes be pulled from the ground. Unfortunately, even small seedlings of some plants have stubborn roots that will prevent removal or cause them to break at the root collar. Plants that break off at the ground will often resprout, and even small root fragments left in the ground may sprout. Therefore, repeated hand-pulling or follow-up with herbicide applications is often necessary.

Removal of uprooted plant material is important. Stems and branches of certain species can sprout roots when laid on the ground. Sometimes the attached seeds can germinate. If material cannot be destroyed by methods such as burning, it should be piled in a secure area, monitored, and new plants should be killed as they appear. Plants can also be taken to a lined landfill for disposal.

**Mechanical removal:**

Mechanical removal involves the use of bulldozers or specialised logging equipment to remove woody plants. Intense follow-up with other control methods is essential after the use of heavy equipment because soil disturbances create favourable conditions for recolonisation by invasive exotic plants as seeds and root fragments germinate. Plans for managing or replanting your site with native plants should be carefully developed prior to implementing any mechanical removal efforts. Mechanical removal may not be appropriate in some natural areas as heavy equipment often disturbs soils and non-target plant communities. Remember to explore the use of existing plants as a nursery crop.

**Water level manipulation:**

Water-level manipulation (either flooding or drainage) is a practice that could be used to remove invasive exotic plant species, but of course manipulation impacts all parts of a habitat, including native species. Such an aggressive control strategy can be considered when a habitat is so badly degraded that the need to reduce invasive exotic species far exceeds any concern for remaining native species. Regular follow-up with herbicides is probably needed to prevent reinvasions. In some cases, planting native species may reduce the susceptibility of aquatic and wetland sites to reinvasion by exotics. In less degraded areas, careful use of integrated methods may be more appropriate.

**Herbicides:**

The use of herbicides, integrated with some of the suggestions above, will help control invasive exotic species in many situations. In many cases, this may be essential for control of invasive exotics. Often, it will take multiple applications as invasive plants can come back. Thus, establishing a monitoring system is important. Anyone who applies herbicides in natural areas should have basic training in herbicide application technology. Particular herbicides are to be used exclusively on certain plants under specified conditions. A basic knowledge of herbicide technology and application techniques is needed for safe handling and effective use of any herbicide.

*Herbicides and wildlife toxicity:* Invasive exotic plant management is often conducted in natural areas with the purpose of maintaining or restoring wildlife habitat. Therefore, it is essential that the herbicides themselves are not toxic to terrestrial wildlife or nearby aquatic organisms. Risk

assessment to wildlife is conducted as part of the registration procedure for herbicides and is determined as the product of hazard and exposure. Hazard is measured as the toxicity of the herbicide to test animals. Exposure depends on the use and persistence of the compound. Herbicide labels should be thoroughly read and understood for their potential impacts on wildlife.

***Re-establishment of native plant species:***

Planting native species can be an effective, though expensive, way to reduce the likelihood of exotic species reinvasion following their removal. Commercial plant nurseries currently provide seeds or entire plants for several wetland and upland species. Care should be taken to obtain plant material suitable to the habitat under consideration. Seeds collected should be ecosourced and taken locally. It often takes several years for plantings to become thoroughly established and extra care (water, nutrients, etc.) and protection (from fire and pests) may be necessary for a while.

***Use of other animals:***

Introduction of animals such as sheep may also be used to control certain invasive exotic plants (only appropriate where you want to maintain a species-rich sward or unpalatable short tussocks, such as silver tussock, sedges, and rushes). However, the environmental impacts of using such nonselective herbivores in natural areas should be carefully considered before implementation.

***Resources for landowners to control weeds:***

All of the above takes time and money. Each region has a Weedbuster coordinator and a source of funds to help landowners to get rid of weeds on their property. To learn more about funding programmes, visit this website – [www.weedbusters.org.nz/funding/initiative\\_fund.asp](http://www.weedbusters.org.nz/funding/initiative_fund.asp).

### **Pest mammals**

Protection of critically threatened native animals and their ecosystems on the New Zealand mainland often require control of multiple introduced animal pests. These mammals have arrived through various human introductions. For example, the ferret is an exotic pet that had been released into the wild and is doing quite well in some areas. Urban areas and rural farmlands can become repository areas where such introduced mammals can thrive and invade any nearby natural areas. They have a huge impact on nesting success of birds and in fact, at great cost, fences have to be constructed around natural remnants to keep out mammalian predators (Figure 26). Some of the more problematic mammals are stoats, rodents, and possums. These mammalian pests have caused the most serious biodiversity declines.



**Figure 26** Predator fence, Riccarton Bush. Photo: Mark Hostetler

## I. Control of pest mammals

The control of pest mammals is difficult and involves a combination of traps, hunting, bait stations, and repellants. Each site is different and one needs a wildlife expert to make recommendations on which control method to use. For more information, please visit the Landcare Research website – [www.landcareresearch.co.nz](http://www.landcareresearch.co.nz). Below we describe some of the more problematic species.

Possums:



**Figure 27** Brushtail possum.  
Source: LandcareResearch

Brushtail possums (*Trichosurus vulpecula*)<sup>71</sup> were among the earliest animals introduced into New Zealand by European settlers (Figure 27). They were first brought from Australia in 1837 to establish a fur industry. By 1922, 36 batches of possums had been imported, mostly from Tasmania where possums were larger and most had the black fur preferred by furriers. These possums and their descendants were liberated at more than 450 places around New Zealand by 1930. The number of possums in New Zealand has been estimated at 70 million. Because there are no predators or competitors here in New Zealand, and suitable habitats are readily available, possums occupy most habitats – all types of native and exotic forest, montane scrublands and tussock grasslands; swamps, farmland, orchard and cropping

areas; and areas in and around towns and cities.

The impact of possums on New Zealand's plants and animals can be quite dramatic. In more diverse communities, which have a greater mix of palatable and unpalatable species, the main initial impact on plants is one of gradual, possibly episodic, depletion. Possums selectively remove some species over many decades, resulting in compositional shifts. The greatest shifts are likely in mixed broadleaved forests in which species preferred by possums are abundant. However, even in the least susceptible forest types some minor but important species disappear (e.g. mistletoes in beech forest).

Until recently, possums were seen as serious conservation pests mainly as a result of their effects on native plants. Although they had sometimes been seen eating birds and insects, few people previously appreciated the role possums played as a direct predator (rather than just a plant-eating competitor) in reducing populations of native birds. That has now changed following a study of the kōkako (a rare bird) in which Landcare Research filmed possums eating kōkako eggs and killing chicks. Four of 19 nests recorded on time-lapse video failed because of possum predation, and possums were probably responsible for a third of the nests suffering predation found during this 4-year study. Possums have also been seen killing or eating eggs, chicks, or adults of at least five other native birds including kererū (native pigeon). During 1996 and 1997, three more sequences of possums threatening adult kererū and eating their eggs were filmed by night-time video cameras.

Several methods are being used to control possums. A relatively new method is biological control. Biological control (immunocontraception) vaccines can reduce possum breeding. The vaccines target the egg coat around the possum egg. The possum egg is surrounded by a protein layer called the zona pellucida (ZP), which is made up of three different proteins, ZP1, ZP2 and ZP3. ZP proteins have been used to develop effective contraceptive vaccines for other species like pigs and horses. Vaccines will stop female possums producing eggs and/or interfere with the fertilisation of any eggs produced. That way, no or very few baby possums will be born, so possum numbers will decline as the adults die off and there are insufficient young to replace them. The biological control vaccine based on the egg proteins will be made into baits and fed to possums from bait stations.

Most of the current control is done by poison baits. The most common is 1080 (sodium monofluoroacetate). Used in carrot, cereal, paste, and gel baits, 1080 is the most widely used poison for situations where possum numbers need to be reduced rapidly over large areas. Carrot baits are

<sup>71</sup> Excerpted from [www.landcareresearch.co.nz/publications/infosheets/possums/](http://www.landcareresearch.co.nz/publications/infosheets/possums/)

screened to remove small pieces so that the risks of birds eating baits are reduced. Cereal baits are used for both aerial and bait station control. Paste baits are used extensively for ground based follow-up maintenance control. Cinnamon is usually added to bait to mask the taste of 1080. Compound 1080 can only be used by licensed operators. Perhaps a more humane alternative for a variety of sites are traps. The range of traps currently available fall into three broad categories: kill, leg-hold, and live-capture traps. For more information – see [www.landcareresearch.co.nz/publications/infosheets/possums/](http://www.landcareresearch.co.nz/publications/infosheets/possums/).

Mammals (especially possums, stoats, and ferrets) can easily lose their ‘fear’ of humans and become a nuisance when homeowners intentionally or inadvertently feed them. **For this reason, one should never feed mammals.** It is extremely important to educate homeowners about the dangers of feeding these animals.

### Invasive insects<sup>72</sup>

In New Zealand there are more than 2000 species of invasive invertebrates already established. Some of these, such as *Vespula* wasps (Figure 28), have become abundant invaders that threaten our native ecosystems. More invasive invertebrates are continually arriving but options are available to landowners to control invasive invertebrates. For example, many effective types of poisoned bait are available to control *Vespula* wasps. **To learn more, visit** [www.landcareresearch.co.nz/research/biocons/invertebrates/](http://www.landcareresearch.co.nz/research/biocons/invertebrates/)



Figure 28 German wasp (*Vespula* spp.)

#### 2.5.5 Securing permanent funding for the management programme

Any management activities are probably going to cost money. How can we secure funding long after the last lot is sold? Although some agencies provide initial and subsequent funding to aid developers and landowners (see Part 1, Management funds for biodiversity), you may have to establish a more permanent funding source. When subdividing land or when a rural landowner has a large parcel, containing both working lands and targeted restoration areas, several options are available to secure funding for management:

- Retain a portion of the lot sales – this could help establish a source of funding; factoring in interest, this could provide money for long-term management activities such as weed control.
- Another creative method is to require that homeowners pay an annual fee to the body corporate to live in a subdivision. This fee would be allocated towards management of the natural areas and maintenance of the environmental education programme.
- In some cases, the landowner could sell a portion of the land to their council or a local land trust. A portion of the sale would be allocated towards a management fund.

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<sup>72</sup> Adapted from Landcare Research website – [www.landcareresearch.co.nz/research/biocons/invertebrates/](http://www.landcareresearch.co.nz/research/biocons/invertebrates/)

- A community development district could be set up whereby the developer sells some land to the city, the city floats a 30-year bond, and the payment of that bond is through annual rates on homeowners living in the subdivision. A portion of the sale would be allocated to annual management and once the bond was paid off, annual homeowner dues would continue to pay for management (see Part 1, Examples of sustainable development programmes and policies from the USA).
- Impact fees for new development or farming enterprises – here, landowners would pay councils money for changing the land use of a property. Funds from such fees would help set up a management fund for the property in question.
- For large properties that have farming, timbering, or hunting leases on site, a portion of monies generated from income-generating enterprises could be used to help manage conserved or restored areas.
- On a broader scale, citizens should lobby local authorities through the LTCCP process to get greater commitment to purchase land for nature conservation.

### 2.5.6 Monitoring the success of your efforts

You may ask – why should I have to monitor the success of my biodiversity strategies? First, by monitoring various social and environmental variables, we can evaluate successes and identify ways to identify unforeseen problems that likely arise over time. Such monitoring will only improve the long-term functionality of the development and providing feedback to local residents will only enhance on-the-ground efforts to conserve natural resources and to promote livability within the community.

Second, local governments and regional councils are required to monitor the success (and failures) of their plans under the Local Government Act and the Resource Management Act. If a development has a monitoring programme set up, such results can aid local and regional governments in reporting the outcomes of various sustainable initiatives. Your local government may be very interested in your monitoring efforts as it will aid them in their State of the Environment reporting. In some cases, a resource consent order may require the developer to monitor a particular variable (e.g. water quality).

How and what do I monitor?

Every monitoring strategy addresses these basic questions: What do I monitor? How do I monitor? Where do I monitor? When do I monitor? and Why do I monitor? These questions are answered depending on local conditions of the site and what various stakeholders in the area deem important to monitor. This entails a good deal of discussion amongst various practitioners and any number of monitoring strategies can be implemented. In terms of biodiversity monitoring, essentially one would need to obtain baseline data on the types and quantity of animals and plants (i.e. what was on the site before construction began) and then obtain post-construction values. The trick is to conduct the survey efforts exactly the same for pre- and post-construction. Environmental monitoring and reporting is essential under the Resource Management Act 1991 (RMA), the Local Government Act 2002 (LGA) and other relevant legislation. This website has useful tools and guidance for how monitoring your site fits in with the RMA, LGA, and local laws – [www.qualityplanning.org.nz/monitoring/index.php](http://www.qualityplanning.org.nz/monitoring/index.php).

One useful monitoring kit for landowners and communities is FORMAK – The Forest Monitoring and Assessment Kit. The kit FORMAK is aimed at assessments and measurements being undertaken by landowners, community groups, iwi and other volunteers who have an interest in an area of forest, but not necessarily much time. The aim is to provide a relatively easy set of measurements that will require around 5 days per year for 1–2 people. The focus is on doing repeat measurements on a regular basis. This will vary from twice a year, to annually, or every 2 years depending on the FORMAK module. For details, see [www.formak.co.nz/](http://www.formak.co.nz/).

Another excellent tool for landowners and homeowners alike to monitor birds, insects, frogs and lizards, mammals, and plants is a programme called New Zealand Biodiversity Recording Network (NZBRN) – see [www.nzbrn.org.nz](http://www.nzbrn.org.nz). This is a very quick and easy way to enter observational and survey data and everybody from children to adults can be involved. The simplest form of monitoring is to take photographs, label and date them, and have them stored for future reference.

### 2.5.7 Producing and distributing a homeowner handout on maintaining biodiverse yards and neighbourhoods



*Volunteers planting natives in a schoolyard, Waipara. Photo: Mark Hostetler*

Many urban areas are situated near natural areas. What people do in their own backyards and neighbourhoods affects both local and nearby wildlife populations. For example, locally, designing and managing at the neighbourhood scale increases biodiversity within the neighbourhood. Yet on a larger scale, how one manages yards and neighbourhoods can have a positive effect on surrounding habitat and this can impact biodiversity on the regional scale. Sometimes neighbourhoods occur between natural areas. These natural areas can be connected by corridors of natural vegetation, thus benefiting wildlife at a larger scale by allowing animals to travel from one natural patch to another.

Collectively, homeowners can do many different things to conserve and restore biodiversity. However, merely planting native vegetation is not enough. We must manage habitat at both section and neighbourhood scales to minimise peoples' impacts. Below are suggestions that target how residents can manage and design their properties and neighbourhoods for biodiversity. **Developers can use this information in a pamphlet for each homeowner that purchases a home in the development.**

#### **Balance lawn and landscaped beds**

Lawn is like concrete to most species of animals. It offers very little food or cover. In general, we recommend reducing the amount of mowed lawn around your house, especially in areas of low traffic such as corners of the section. By simply not mowing, you will be creating shelter and food for many animal species. Over time, unmowed areas contain more plant species than mowed areas. This plant diversity attracts more wildlife. Birds are attracted to areas that are structurally diverse. These areas provide shelter in which to hide from predators or build nests. Furthermore, the diversity of plants provides more feeding opportunities. More fruits and seeds are available in these unmowed areas. Most importantly, diverse areas attract more insects and thus the wide variety of birds that eat insects.

Why does mowing favour grass? Mowing favours grass because it is adapted to being cut down. When you leave an area unmowed, other plants will gradually replace the grass. These plants may sprout from seeds already in the soil or from seeds that have been deposited from the surrounding area. Wind and water can bring a wide variety of seeds. As an area becomes more diverse, animals will visit the area carrying seeds back and forth with them. Seeds can be dispersed after sticking to an animal's body or being excreted in their droppings. To help speed up the replacement of some areas of lawn, you can remove the grass and plant seeds of **Native** wildflowers, tussocks, or shrubs that are adapted to the conditions in that part of the yard (i.e. sunny, shady, wet, dry, etc.). But be aware that these germinating plants will require ongoing maintenance as with any garden. For example, short silver tussocks will otherwise be infiltrated by tall, untidy exotic grasses. Maintenance levels will only drop substantially if you install slightly taller shrubs and plants. In fact, gardening is all about holding

succession back at some desired state. The earlier the stage, usually the more maintenance and targeted the weeding will be.

*Replace some lawn with ground cover plants:* Another option is to replace some lawn with ground cover plants, which are more valuable to wildlife than grass. Compared with ground cover plants, lawn grasses require a lot of maintenance such as mowing, fertilising and watering, all of which have high energy costs in electricity, water, and other natural resources. In general, sections have many areas where native ground covers would be attractive. These places might include under trees and bushes or along a privacy fence. Ground covers also provide food and cover for small animals. Be aware though of ground cover plants that may be categorised as invasive exotic plants that could mistakenly be used (e.g. wandering Willy plant - *Tradescantia fluminensis*, aluminium plant, ivy). More information on the benefits of ground covers can be found at [hort.ifas.ufl.edu/gt/groundcoverenergy/groundcoverenergy.htm](http://hort.ifas.ufl.edu/gt/groundcoverenergy/groundcoverenergy.htm).

*Add islands of native vegetation:* Islands of landscaped vegetation are also very helpful to wildlife. These can be planted with native ground cover, wildflowers, shrubs, and trees. If possible, locate the islands so they are near each other. Islands can also be located near unmowed areas of a community. Since animals that cross open areas are at greater risk of being prey for other species, grouping islands close together helps to give them cover. Overall, the nearer they are to each other, the more likely an animal will cross from one island to the next. Small, ground-dwelling wildlife species benefit greatly from islands of vegetation. Grouping islands of vegetation even benefits birds, as they like to be near shelter while foraging for food.

*Plant a butterfly garden:* For butterfly habitat, it is important to add plants for both the adult butterflies and their larvae (caterpillars). Adult butterflies and their larvae often feed on different species of plants. For information on which plants are utilised by butterfly larvae and by adults, look for New Zealand butterfly books. When planting your butterfly garden, keep in mind that the plants butterfly larva (caterpillars) use as food will be munched on and may look a little tattered at times.

Another way to help butterflies is to create a small, bare area of moist sand in your yard. This moist area is attractive to male butterflies in particular as they sip water from damp sand to obtain needed salts/minerals. This behaviour is called 'puddling.'

### **Increase vertical layering**

Looking across your landscape, do you see large trees, low grass, and nothing in between? Increasing the diversity of plant structure between the ground and the tree canopy is called 'vertical layering.' Planting shrubs or ground covers below some of your trees will benefit wildlife. Wildlife species have more cover and feeding opportunities when yards contain a variety of vegetation in different sizes and heights. Clumps (or islands) of vegetation with plants of different heights are best. One example of vertical layering is a tree with medium-sized shrubs surrounding it and some ground covers planted around the shrubs. Whenever possible, use native plants that are suitable for site conditions, as birds and other small animals are adapted to local plant species.

### **Create lizard habitat<sup>73</sup>**

Lizards can thrive in suburban gardens and rural properties if their needs for food and shelter are met. Lizards primarily eat insects but they do also supplement their diet with fruit. Plant fruit-bearing shrubs and vines, such as the divaricating *Coprosma propinqua*, *C. crassifolia*, *Melicytus alpinus*, shrubby tororaro – *Muehlenbeckia astonii* and vines like scrambling pōhuehue, *Muehlenbeckia complexa*. Tussocks are good too, as they attract a variety of small insects for lizards to eat.

You can also make a lizard home out of Onduline. Onduline is an extremely tough, lightweight, corrugated roofing and cladding product made from organic fibres saturated with bitumen. Sheets are 2 metres long and can be cut into smaller pieces (290 mm × 400 mm or larger) with a handsaw or skillsaw. These should be stacked two or three high with small stones in between the layers to provide predator proof gaps – too narrow for rats and mice.

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<sup>73</sup> Source – Attracting lizards to gardens in Canterbury, [www.doc.govt.nz/templates/page.aspx?id=33127](http://www.doc.govt.nz/templates/page.aspx?id=33127)

Place your lizard home in a warm dry sunny area with good cover such as divaricating shrubs, tussocks and rock piles. Once in place do not disturb your lizard home. Prospective tenants will abandon habitat that is frequently disturbed.

### **Provide water**

Water is an essential part of productive wildlife habitats. Wildlife will benefit from any water source provided in a community, such as a birdbath and/or a small pond. Ponds are not only beautiful, but also attract a variety of species and enhance amphibian breeding. Retention ponds can also be designed for wildlife. Important pond features include gently sloping banks and littoral shelves for native plants to grow and for wading birds to forage. See information contained within Part 2 Construction – retention and detention ponds. If worried about mosquitoes, install a fountain within the pond to help disturb the water (mosquitoes typically like stagnant water). Also, a strain of *Bacillus thuringiensis* (B.t.) is a live microorganism that produces spores that are specifically toxic to mosquito larvae. Production of B.t. cakes are available in some places over the counter and you can place these in the ponds (particularly small ponds) to control mosquito larvae.

### **Plant native vegetation**

Whenever possible, landscape your development and its yards with native plant species. Landscaping with plants that are native to New Zealand provides better food and cover for wildlife. Once established, natives generally require less care and resources to maintain than non-native plants (i.e. exotics). However, exotic plants can also be quite adapted to local conditions and fare just as well or better than natives. In fact, when they do too well, they expand into natural areas and are categorised as an invasive exotic. Thus, if using an exotic plant, be very sure that it is not listed as an invasive exotic plant (see Expelling exotics section). Also, see how much care the exotic plant requires; if recommendations are annual or monthly fertilisations, pesticide sprayings, and application of herbicides – look for another plant. As with all plants, newly planted native plants must be watered until they are established. But once established, locally sourced native plants are adapted to local water and soil conditions and should require minimal maintenance. To locate sources of native plants, see [www.bush.org.nz/nursery/](http://www.bush.org.nz/nursery/).

Even with native plants, it is important to plant them in the conditions optimal to their specific growth needs. These growth requirements might include conditions such as full sun, part sun/part shade, full shade, wet soil, dry soil, acidic soil, sandy soil, etc. When establishing a landscaping plan it is best to begin with a survey of the conditions on the development site. Evaluate which areas receive abundant sunshine, which areas are predominantly shady, where the soil is frequently wet, how conditions change between the morning and the afternoon, etc. Once the dynamic natural conditions of the development site are understood, the appropriate native plants can then be purchased.

Each native plant species is a member of a community that includes other plants, animals, and microorganisms. The natural balance keeps each species in check. Plants thrive in conditions to which they are adapted. However, other local organisms (e.g. insects) prevent plants from spreading uncontrolled. Thus, native species rarely become invasive, although some native species can become so if conditions are right (e.g. perhaps a natural community is missing important checks and balances). Unfortunately, some exotic plants imported from other areas to New Zealand have limited local organisms to keep their spread in check, and they become listed as invasive exotic. One example is the use of north island lacebark tree (*Hoheria populenea* and *Hoheria sexstylosa*) in the south island.

For more information on native plants, visit the Plant Conservation Network ([www.nzpcn.org.nz](http://www.nzpcn.org.nz)) for important links and also use the New Zealand Ecological Restoration Network ([www.bush.org.nz/](http://www.bush.org.nz/)).

### **Manage pets**

Pets can have a huge impact on wildlife populations. Loose dogs often harass and even kill a wide variety of wildlife species. Cats are extremely good at hunting. Their small size, agility, and speed are a lethal combination for the small animals on which they prey. However, cats are good at catching mice and rats. Scientists estimate that cats are responsible for killing many New Zealand species of birds and reptiles. Cats are a primary culprit for the local extirpation and global extinction of several New Zealand animals. Just because a cat is well-fed does not mean that it won't hunt. Cats and dogs hunt because it is in their nature to do so, not necessarily for food. A well-fed pet or stray is even more adept at hunting since it has a lot of energy. Pet predation is especially problematic in residential

developments that attract birds and other wildlife. Strict pet management guidelines are an important part of wildlife habitat preservation plans within residential communities.

Keeping cats exclusively indoors is strongly supported by the animal welfare, veterinary, conservation, and scientific communities. Making sure that cats stay indoors will keep them safe from other strays, traffic, and many diseases that can be transmitted to pets through contact with wild animals. Information on the American Bird Conservancy's *Cats Indoors* campaign is available on the Web at [www.abcbirds.org/cats/catsindoors.htm](http://www.abcbirds.org/cats/catsindoors.htm). Additional information can be found on the Humane Society of the United States website at [www.hsus.org/programs/companion/pet\\_cruelty/freeroaming\\_statement.html](http://www.hsus.org/programs/companion/pet_cruelty/freeroaming_statement.html) and the National Audubon Society website at [www.audubon.org/bird/cat/](http://www.audubon.org/bird/cat/). Also, the biosecurity website for New Zealand contains lots of information about the types of introduced animals and plants that are a threat and what to do about them ([www.biosecurity.govt.nz](http://www.biosecurity.govt.nz)). One somewhat new method is to equip cats with a bib to prevent them from catching animals. This was tested in one study and showed that it could prevent 81% of the cats from catching birds<sup>74</sup>.

Releasing exotic pets can also cause dire consequences for natural habitats and wildlife. 'Exotic' pets include parrots, toads, and almost any animal bought at a pet store since most of these animals are originally from other parts of the world. If these exotic pets establish themselves in the wild, they may actually compete with native wildlife for food and shelter. Furthermore, some carry diseases that may infect local wildlife. For example, if certain imported aquarium fish are released into streams or lakes, they can prey on native species<sup>75</sup>.

### Reduce pesticide use

Anything a homeowner can do to reduce pesticides in a community will benefit wildlife. Instead of targeting one species of insect, most pesticides will kill any type of insect that comes in contact with it. Thus, when backyards, golf courses, and other community green spaces are sprayed with pesticides to kill one pest species, many other beneficial species are also killed. Almost all wildlife species eat insects in some way. **Most birds, reptiles, and amphibians eat insects.** Even if they do not eat insects directly, their prey eats insects. For example, some hawks eat smaller birds. Some of these smaller birds eat insects. Ultimately, good insect diversity helps promote good wildlife diversity.

Additionally, many insects provide valuable services in the environment such as plant pollination. Insect pollinators include flies, bees, wasps, beetles, moths, butterflies, and other insects. As they feed on flower nectar, they carry pollen from flower to flower, which promotes plant reproduction. Without pollinating insects, some plant species may not reproduce in a local area. This change in plant diversity ultimately affects wildlife diversity. These plants might have provided food and shelter for various animals. Without the plants, many wildlife species may not be able to survive in the immediate area.

Instead of broadcasting pesticides over a large area, it is better to spot treat or use baits or traps that target one pest species (e.g. pheromone baits). Spraying pesticides across a large area also kills some of the natural insect predators of pest insects (e.g. robber flies, parasitoid wasps). Unfortunately, the pests actually come back much quicker than their predators. Another good approach is to encourage insects that eat pest species. For example, encouraging ladybirds to live in the landscaping throughout a development is a great way to control aphids. It is also useful to allow spiders and other native insect predators to exist around homes within a community as they eat many kinds of pest insects. Did you know that some birds eat spiders? Even some plants, such as marigolds, deter insects.

### Expand the scale of the habitat

The required habitat for many species is much larger than one or two properties. Consider site-wide planning to create large areas of wildlife habitat. As mentioned earlier, large patches of wildlife habitat will draw more species into the community overall. Many wildlife species prefer large patches of their ideal habitat (such as open meadow, shrubs, or mixed forest). Some species primarily respond to one

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<sup>74</sup> Michael C, Thomas S, Bradley S, McCutcheon H 2007. Reducing the rate of predation on wildlife by pet cats: The efficacy and practicability of collar-mounted pounce protectors. *Biological Conservation* 137: 341–348

<sup>75</sup> For example of one report, see [www.rsnz.org/publish/nzjmf/2004/044.php](http://www.rsnz.org/publish/nzjmf/2004/044.php)

type of habitat. Other species like a mixture of different habitats. For example, pūkeko primarily like wetland habitats while Australasian harrier hawks like a mixture of trees and open areas in drylands. Individual properties – when combined across a neighbourhood – could provide larger patches of natural habitat.

Larger fauna respond to landscape structure, such as tree canopy, at much broader scales than do smaller species. For example, a hawk will respond to landscape structure across a whole neighbourhood. Yet a fantail will probably respond to landscape structure within one or two backyards.

Communities designed for biodiversity should have educational materials that will encourage neighbours to design wild areas at their property lines or on adjacent corners of their properties. After all, even if the developer had designed over 50% of the lots as natural/native, a homeowner could decide to change this to turf. Even creating wildlife habitat with neighbours that are not adjacent creates a number of different habitat patches. This design can make developed communities attractive to more animal species and ultimately to people.

## Part Three: Designing a biodiverse subdivision

Your development firm has been shortlisted for a bid to build a residential development on a 100-ha parcel of land near Nelson. The landowners feel that 250 houses should provide a profitable business venture. The owners specifically want to conserve biodiversity and other natural resources such as water and energy. The competition for the project is intense and many local planners believe this parcel of land provides an opportunity to set a benchmark for how surrounding land might be developed. Your development firm is finalising its bid documents and you've been asked to assist with the following aspects of the site plan:

### Design

- Location of major roads, homes, amenities (community parks), and conservation areas
- Density of housing and general location of house lots (i.e. number of homes per hectare)
- Connectivity with surrounding natural areas

### Construction

- Steps taken to minimise impacts during construction
- Landscaping plan for built areas (e.g. sections and common areas)
- Integration with other green features such as energy and water conservation and low impact stormwater management and design

### Post-construction

- Management and restoration plan for conservation areas and other significant areas of the property (must indicate source of funding)
- Steps taken to engage the residents of the community

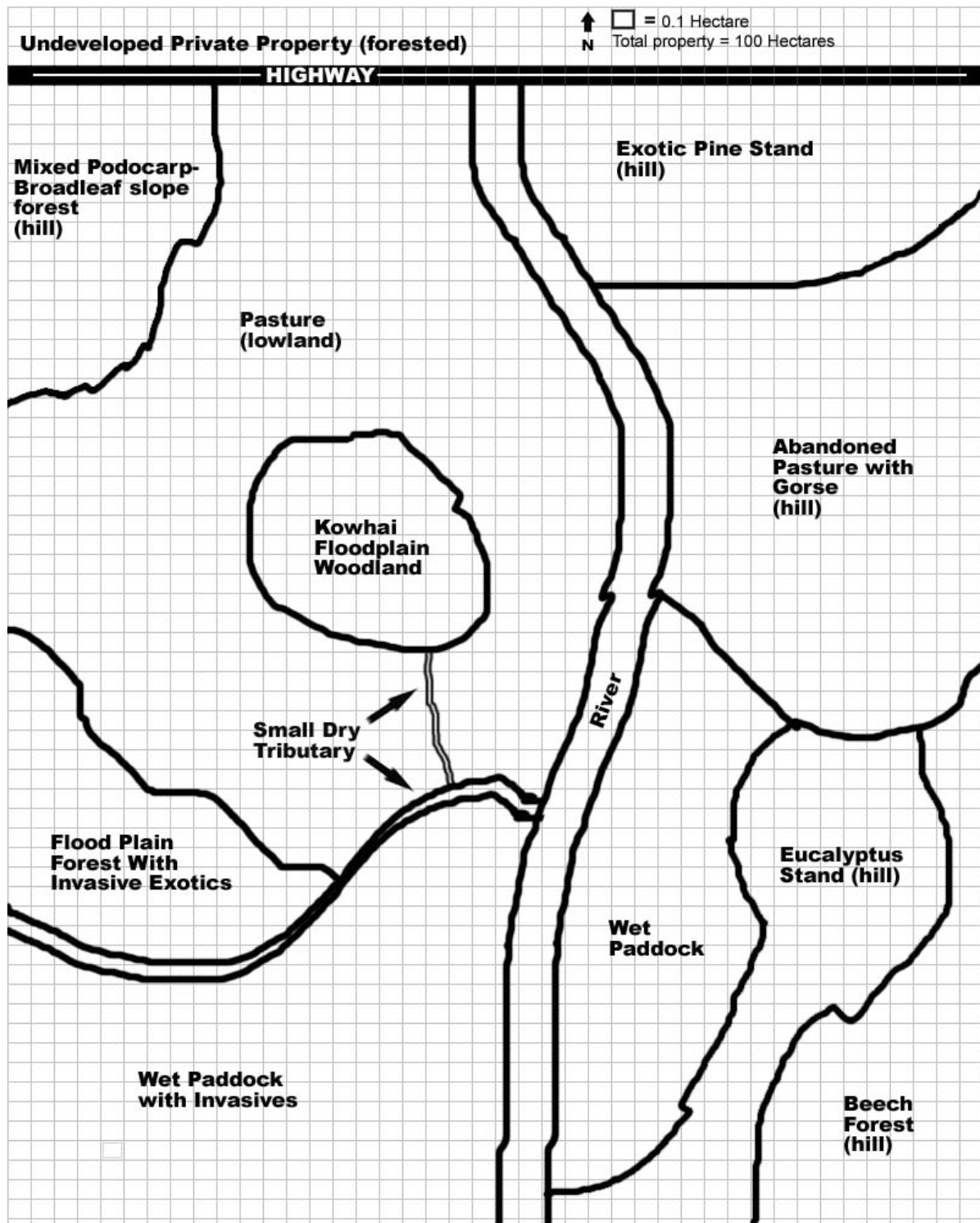
### The land consists of the following habitats:

- Mixed podocarp–broadleaf slope forest and beech forest
- Small river (all along the river on both sides is a stand of crack willow)
- Floodplain forest and remnant kōwhai floodplain woodland
- Wet paddocks
- Abandoned cattle/sheep pasture, and exotic forest stands
- Paddocks, forests, and abandoned pasture contains invasive pampas grass and gorse

### Other critical details:

- Undeveloped private property to the north of the road
- 2000-ha conservation easement to the east of the land (habitat is a combination of beech forest and pasture with recently planted native vegetation)
- Wet paddock connected to natural wetlands to the south
- Wet paddocks were previously a Maori food-gathering place (Mahinga Kai)
- Single-family residential community to the west of the land
- Breeding birds along the river that could be disturbed by humans
- possums have been found on site

Create an outline of strategies that address the *design*, *construction*, and *post-construction* issues for this site. Use the diagram on the next page to draw in homes, roads, open space, etc.



## Food for thought

- ✓ In your opinion, what are the most serious threats to biodiversity in New Zealand? Why?
- ✓ Which of these threats are the most difficult for you to reduce within your property? What makes it difficult?
- ✓ Do you plan to do anything different as a result of this continuing education course? If so, what will you do differently?
- ✓ In your opinion, which of the major ecological, social, and economic benefits of preserving biodiversity are the most attractive to you? Why?

## References and resources

### PART 1 Key concepts and players: preliminaries

#### Introduction and objectives

Biodiversity hotspots

[www.biodiversityhotspots.org](http://www.biodiversityhotspots.org)

Clarkson BD, Wehi PM, Brabyn LK 2007. A spatial analysis of indigenous cover patterns and implications for ecological restoration in urban centres, New Zealand. *Urban Ecosystems* 10: 441–457.

Comparing Florida's environmental risks: Risks to Florida and Floridians (published September 1995 by the Florida Center for Public Management)

[www.pepps.fsu.edu/FCER/final.pdf](http://www.pepps.fsu.edu/FCER/final.pdf)

Leathwick J, Morgan F, Wilson G, Rutledge D, McLeod M, Johnston K 2003. Land environments of New Zealand: Technical guide. David Bateman, Auckland, New Zealand

Smart Communities Network: Green development introduction (U.S. Department of Energy)

[www.sustainable.doe.gov/greendev/gdintro.shtml](http://www.sustainable.doe.gov/greendev/gdintro.shtml)

Statistics New Zealand

[www.stats.govt.nz](http://www.stats.govt.nz)

Suitable land for development in New Zealand

<http://transurban.co.nz/pubgrowth.html>

Walker RG 2002. Taxonomic and ecological profiles of rarity in the New Zealand vascular flora. *New Zealand Journal of Botany* 40: 73–93.

#### Benefits to conserving and restoring biodiversity

Costanza R, d'Arge R, de Groot R, Farber S, Grasso M, Hannon B, Limburg K, Naeem S, O'Neill RV, Paruelo J, Raskin RG, Sutton P, van den Belt M 1997. The value of the world's ecosystem services and natural capital. *Nature* 387: 253–260.

Economic benefits to green development (Smart Communities Network – USA)

[www.smartcommunities.ncat.org/greendev/benefits.shtml](http://www.smartcommunities.ncat.org/greendev/benefits.shtml)

The Environmental Literacy Council ('About Us' page)

[www.enviroliteracy.org/subcategory.php/1.html](http://www.enviroliteracy.org/subcategory.php/1.html)

Hotlanta: Geographers demonstrate Atlanta is an 'urban heat island' that creates its own weather and causes thunderstorms (UGA: Press Release 12 April 1999)

[www.uga.edu/columns/990412/campnews.html](http://www.uga.edu/columns/990412/campnews.html)

Krajick K 1999. To Hell and back. *Discover Magazine*. Pages 76–82.

Macie EA, Hermansen LA 2002. Human influences on forest ecosystems: The Southern Wildland–Urban Interface Assessment. General Technical Report SRS-55, U.S. Department of Agriculture; Forest Service; Southern Research Station, Asheville, NC.

Millennium Ecosystem Assessment synthesis report

[www.millenniumassessment.org/en/index.aspx](http://www.millenniumassessment.org/en/index.aspx)

Nelson Biodiversity Strategy 2007 to 2009 Report

[www.nelsoncitycouncil.co.nz](http://www.nelsoncitycouncil.co.nz)

New Zealand Ministry for the Environment

[www.mfe.govt.nz/](http://www.mfe.govt.nz/)

Rivers, Trails and Conservation Assistance of the National Park Service. Economic impacts of protecting rivers, trails, and greenway corridors: A resource book.

[www.nps.gov/pwro/rtca/econ\\_index.htm](http://www.nps.gov/pwro/rtca/econ_index.htm)

Stedman RC 2003. Is it really just a social construction? The contribution of the physical environment to sense of place. *Society & Natural Resources* 16: 671–685.

Wells NM, Evans GW 2003. Nearby nature: A buffer of life stress among rural children. *Environment and Behavior* 35: 311–330.

### **Animal habitat selection**

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Hostetler ME 1999. Scale, birds, and human decisions: a potential for integrative research in urban ecosystems. *Landscape and Urban Planning* 45: 15–19.

Hostetler ME, Holling CS 2000. Detecting the scales at which birds respond to landscape structure in urban landscapes. *Urban Ecosystems* 4: 25–54.

Hostetler ME, Knowles-Yanez K 2003. Land use, scale, and bird distributions in the Phoenix metropolitan area. *Landscape and Urban Planning* 62: 55–68.

### **Natural communities in New Zealand**

Biocommunity

[www.biocommunity.org.nz/](http://www.biocommunity.org.nz/)

Department of Conservation

[www.doc.govt.nz/](http://www.doc.govt.nz/)

Landcare Research

[www.doc.govt.nz/](http://www.doc.govt.nz/)

Leathwick J, Morgan F, Wilson G, Rutledge D, McLeod M, Johnston K (2003) Land environments of New Zealand: Technical Guide. David Bateman, Auckland, New Zealand.

NZ Native Biodiversity

[www.biodiversity.govt.nz/resources/guides/ecological.html#NHMS](http://www.biodiversity.govt.nz/resources/guides/ecological.html#NHMS)

Roon van M, Knight S 2004. Ecological context of development. New Zealand perspectives. Oxford University Press, Melbourne, Australia.

Walker RG 2002. Taxonomic and ecological profiles of rarity in the New Zealand vascular flora. *New Zealand Journal of Botany* 40: 73–93.

### **New Zealand policy and land development**

New Zealand's national biodiversity strategy

[www.biodiversity.govt.nz/index.html](http://www.biodiversity.govt.nz/index.html)

Key New Zealand players implementing the national biodiversity strategy

- Department of Conservation – [www.doc.govt.nz/](http://www.doc.govt.nz/)

- Ministry for the Environment –[www.mfe.govt.nz/](http://www.mfe.govt.nz/)
- Ministry of Agriculture and Forestry –[www.maf.govt.nz/](http://www.maf.govt.nz/)
- Ministry of Fisheries –[www.fish.govt.nz/](http://www.fish.govt.nz/)
- Ministry of Research, Science and Technology –[www.morst.govt.nz/](http://www.morst.govt.nz/)
- Foundation for Research, Science and Technology –[www.frst.govt.nz/](http://www.frst.govt.nz/)
- Te Puni Kokiri/Ministry of Maori Development –[www.tpk.govt.nz/](http://www.tpk.govt.nz/)
- Ministry of Foreign Affairs and Trade –[www.mfat.govt.nz/](http://www.mfat.govt.nz/)

Roon van, M. and Knight, S. 2004. Ecological context of development. New Zealand perspectives. Oxford University Press, Melbourne, Australia.

Your guide to the Resource Management Act

[www.mfe.govt.nz/publications/rma/rma-guide-aug06/html/page2.html](http://www.mfe.govt.nz/publications/rma/rma-guide-aug06/html/page2.html)

### **Financial strategies for conserving or restoring open space**

Conservation Easements (Christchurch City Council)

[www.ccc.govt.nz/Parks/TheEnvironment/conservation.asp](http://www.ccc.govt.nz/Parks/TheEnvironment/conservation.asp)

Conservation Easements (Christchurch City Council)

[www.ccc.govt.nz/Christchurch/Heritage/Information/ConservationCovenants.asp](http://www.ccc.govt.nz/Christchurch/Heritage/Information/ConservationCovenants.asp)

Conservation Easements (QE II National Trust)

[www.qe2.org.nz](http://www.qe2.org.nz)

Example of a Community Development District (Eastlake Oaks-USA)

<http://eastlakeoaks.tripod.com/elo/id3.html>

Introduction to Transferable Development Rights (UGA: Office of Public Service and Outreach)

<http://outreach.ecology.uga.edu/etowah/documents/tdr.pdf>

Land Preservation in USA (Land Trust Alliance)

[www.lta.org/](http://www.lta.org/)

NZ Department of Conservation

[www.doc.govt.nz](http://www.doc.govt.nz)

NZ Landcare Trust

[www.landcare.org.nz/](http://www.landcare.org.nz/)

Paying Private Landowners to Conserve Wildlife Habitat: A Unique Approach to Conservation (UF: IFAS document WEC-142)

<http://edis.ifas.ufl.edu/UW138>

QE II National Trust

[www.qe2.org.nz](http://www.qe2.org.nz)

Transfer of Development Rights (Ohio State University Extension Fact Sheet CDFS-1264-98)

<http://ohioline.osu.edu/cd-fact/1264.html>

The Trust for Public Land (USA)

[www.tpl.org](http://www.tpl.org)

Walker S, Price R, Rutledge D 2005. New Zealand's remaining indigenous cover: recent changes and biodiversity protection needs. Landcare Research Report.

### **Sustainable development policies and programmes – USA**

Florida Century Commission Report on Sustainability and Policy  
[www.commentmgr.com/projects/1148/docs/CC%20UF%20Applied%20Sustainability.pdf](http://www.commentmgr.com/projects/1148/docs/CC%20UF%20Applied%20Sustainability.pdf)

Florida Community Development Districts (CDD)  
[www.flsenate.gov/statutes/](http://www.flsenate.gov/statutes/) (click through to Title XIII: Chapter 190 – Community Development Districts)

Green certification organisations in the United States  
[www.auduboninternational.org](http://www.auduboninternational.org) (Audubon International)  
[www.usgbc.org/](http://www.usgbc.org/) (United States Green Building Council)  
[www.floridagreenbuilding.org/db/](http://www.floridagreenbuilding.org/db/) (Florida Green Building Coalition)

In addition to the certification programmes listed above, CITYgreen is an excellent resource to assist developers with their land-use goals while creating valuable natural amenities that will both increase property values and help to reduce energy costs within individual buildings.  
[www.americanforests.org/productsandpubs/citygreen/](http://www.americanforests.org/productsandpubs/citygreen/)

Incentive-based policies for green development  
<http://edis.ifas.ufl.edu/UW254> (Policies that Address Sustainable Site Development)  
<http://edis.ifas.ufl.edu/UW253> (Policies that Address Sustainable Landscaping Practices)  
<http://edis.ifas.ufl.edu/UW252> (Policies that Address Sustainable Building Practices)

Program for Resource Efficient Communities  
[www.buildgreen.ufl.edu](http://www.buildgreen.ufl.edu)

Smart communities network (Model sustainable development codes and ordinances)  
[www.smartcommunities.ncat.org/management/codtoc.shtml](http://www.smartcommunities.ncat.org/management/codtoc.shtml)

Smart Growth Program (Environmental Protection Agency)  
[www.epa.gov/dced/](http://www.epa.gov/dced/)

Sustainable development programmes and policies from the USA

US Department of Energy's Center of Excellence for Sustainable Development  
[www.smartcommunities.ncat.org/](http://www.smartcommunities.ncat.org/)

Wetland mitigation banking (National Mitigation Banking Association United States)  
[www.mitigationbanking.org/](http://www.mitigationbanking.org/)

## **PART 2 How to do it: design, construction, and post-construction**

### **Phase 1: Design**

Arendt RG 1996. Conservation design for subdivisions: A practical guide to creating open space networks. Island Press, Washington, DC.

Christchurch City Council waterways and wetlands publications (for natural wetland treatment of stormwater)  
[www.ccc.govt.nz/Parks/Publications/](http://www.ccc.govt.nz/Parks/Publications/)

Ecological design manual for Lake County (East Central Florida Regional Planning Council)  
[www.ecfrpc.org/Files/Projects/eco\\_design\\_manual.pdf](http://www.ecfrpc.org/Files/Projects/eco_design_manual.pdf)

Ewing R 1996. Best development practices: Doing the right thing and making money at the same time. American Planning Association, Chicago, IL.

Groundwater basics (U.S. Environmental Protection Agency)  
[www.epa.gov/seahome/groundwater/src/basics.htm#menu](http://www.epa.gov/seahome/groundwater/src/basics.htm#menu)

Hinewai Reserve, Banks Peninsula  
[www.rsnz.org/publish/nzjb/1994/32.php](http://www.rsnz.org/publish/nzjb/1994/32.php)

Ignatieva, M., Meurk, C., Van Roon, M., Simcock, R., and G. Stewart. 2008. How to Put Nature into Our Neighbourhoods – application of Low Impact Urban Design and Development (LIUDD) principles, with a biodiversity focus, for New Zealand Developers and Homeowners. Landcare Research Science Series No.35. Manaaki Whenua Press.

Landscaping for wildlife (Florida Wildlife Extension)  
[www.wec.ufl.edu/extension/landscaping.htm](http://www.wec.ufl.edu/extension/landscaping.htm)

LIUDD Case Studies in New Zealand (Landcare Research and University of Auckland)  
<http://cs.synergine.com>

Macie EA, Hermansen LA 2002. Human influences on forest ecosystems: The Southern Wildland-Urban Interface Assessment. General Technical Report SRS-55, U.S. Department of Agriculture; Forest Service; Southern Research Station, Asheville, NC.

Meurk CD, Hall GMJ 2006. Options for enhancing forest biodiversity across New Zealand's managed landscapes based on ecosystem modelling and spatial design. New Zealand Journal of Ecology 30: 131–146.

Tūi and kererū: Helping New Zealand icons in your backyard. 2008 Pamphlet produced by Department of Conservation Southland Conservancy; [www.doc.govt.nz](http://www.doc.govt.nz)

Millennium Ecosystem Assessment: Strengthening capacity to manage ecosystems sustainably for human well-being  
[www.millenniumassessment.org/en/index.htm](http://www.millenniumassessment.org/en/index.htm)

NASA's Observatorium: Hydrologic Cycle (National Aeronautics and Space Administration)  
<http://observe.arc.nasa.gov/nasa/earth/hydrocycle/hydro1.html>

NZ Ecological Restoration Network  
[www.bush.org.nz/](http://www.bush.org.nz/)

Project for public spaces: Building community, creating places, using common sense  
[www.pps.org/](http://www.pps.org/)

Society for Ecological Restoration (SER)  
[www.ser.org/](http://www.ser.org/)

Department of Conservation (authors Mark Davis and Colin Meurk). 2001. Protecting and restoring our natural heritage: a practical guide.  
[www.doc.govt.nz/templates/MultiPageDocumentTOC.aspx?id=42685](http://www.doc.govt.nz/templates/MultiPageDocumentTOC.aspx?id=42685)

Enviro-Mark NZ (help businesses offset environmental impacts of their activities)  
[www.landcareresearch.co.nz/services/sustainablesoc/enviromark/client\\_services.asp](http://www.landcareresearch.co.nz/services/sustainablesoc/enviromark/client_services.asp)

Hinewai Reserve, Banks Peninsula  
[www.rsnz.org/publish/nzjb/1994/32.php](http://www.rsnz.org/publish/nzjb/1994/32.php)

## **Phase 2: Construction**

Creating native shelterbelts – Establishing shelter in Canterbury with nature conservation in mind: A practical guide for the true Cantabrian  
[www.lincoln.ac.nz/story10364.html#j5](http://www.lincoln.ac.nz/story10364.html#j5)

Dark Sky

[www.darksky.org/](http://www.darksky.org/)

Department of Conservation (authors Mark Davis and Colin Meurk). 2001. Protecting and restoring our natural heritage: a practical guide.

[www.doc.govt.nz/templates/MultiPageDocumentTOC.aspx?id=42685](http://www.doc.govt.nz/templates/MultiPageDocumentTOC.aspx?id=42685)

Efficient irrigation systems

[www.floridaswater.com/](http://www.floridaswater.com/)

Florida Wildlife Extension (UF Institute of Food and Agricultural Sciences)

[www.wec.ufl.edu/extension/](http://www.wec.ufl.edu/extension/)

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Native plant nurseries (New Zealand)

[www.bush.org.nz/nursery/](http://www.bush.org.nz/nursery/)

New Zealand Water & Wastes Association, On-Site Stormwater Management Guideline

[www.nzwerf.org.nz/publications/sw602/sw602.html](http://www.nzwerf.org.nz/publications/sw602/sw602.html)

Right plant in the right place (New Zealand)

[www.bush.org.nz/planterguide/index.html](http://www.bush.org.nz/planterguide/index.html)

Ruppert KC, White C, Dessaint P, Gilman E, Foerste E, 2005. Trees and construction: keeping trees alive in the urban forest. Program for Resource Efficient Communities, University of Florida, Gainesville, FL.

Selection and design of stormwater devices – Christchurch City Council

[www.nzwwa.org.nz/section3.pdf](http://www.nzwwa.org.nz/section3.pdf)

Stormwater treatment devices – Auckland Regional Council

[www.arc.govt.nz/arc/index](http://www.arc.govt.nz/arc/index)

Streamside planting guide – Christchurch City Council Parks & Recreation

[www.ccc.govt.nz/parks/theenvironment/streamside.asp](http://www.ccc.govt.nz/parks/theenvironment/streamside.asp)

Sustainable living in New Zealand

[www.sustainableliving.org.nz/](http://www.sustainableliving.org.nz/)

Case studies of New Zealand developments that have utilised low impact stormwater treatment trains and other sustainable design practices

<http://cs.synergine.com>

### **Phase 3: Post-construction**

DeLorme D, Hagen S, Stout I 2003. Consumers' perspectives on water issues: directions for educational campaigns. *Journal of Environmental Education* 34(2): 28–35.

Hostetler ME, Swiman E, Prizzia A, Noiseux K 2008. Reaching residents of green communities: Evaluation of a unique environmental education program. *Applied Environmental Education and Communication*. In Review.

Lenth BA, Knight RL, Gilgert WC 2006. Conservation value of clustered housing developments. *Conservation Biology* 20: 1445–1456.

Noiseux K, Hostetler ME 2007. Are new homeowners in green developments ready to live green? Planning Education and Research. In review.

Town of Harmony Environmental Education Program  
[www.wec.ufl.edu/extension/gc/harmony/](http://www.wec.ufl.edu/extension/gc/harmony/)

Youngentob K, Hostetler ME 2005. Is a new urban development model building greener communities? Environment and Behavior 37: 731–759.

#### Expelling invasive exotics

Auckland Regional Council – pest plants  
[www.arc.govt.nz/environment/plants-and-animals/pest-plants/pest-plants\\_home.cfm](http://www.arc.govt.nz/environment/plants-and-animals/pest-plants/pest-plants_home.cfm)

Biological Control of Weeds Book (Landcare Research)  
[www.landcareresearch.co.nz/research/biocons/weeds/book/](http://www.landcareresearch.co.nz/research/biocons/weeds/book/)

Biosecurity New Zealand  
[www.biosecurity.govt.nz/pests-diseases/plants/accord.htm](http://www.biosecurity.govt.nz/pests-diseases/plants/accord.htm)

Landcare Research Biocontrol of Weeds Programme  
[www.landcareresearch.co.nz/research/category\\_list.asp?SciCategory\\_ID=22](http://www.landcareresearch.co.nz/research/category_list.asp?SciCategory_ID=22)

Landcare Research pest control (insects)  
[www.landcareresearch.co.nz/research/biocons/invertebrates/](http://www.landcareresearch.co.nz/research/biocons/invertebrates/)

Landcare Research pest control (mammals)  
[www.landcareresearch.co.nz/research/category\\_list.asp?SciCategory\\_ID=21](http://www.landcareresearch.co.nz/research/category_list.asp?SciCategory_ID=21)

Landcare Research weeds information  
[www.landcareresearch.co.nz/education/weeds/weedinfoa.asp](http://www.landcareresearch.co.nz/education/weeds/weedinfoa.asp)

WeedBusters  
[www.weedbusters.org.nz](http://www.weedbusters.org.nz)

Weeds newsletter (Landcare Research)  
[www.landcareresearch.co.nz/publications/newsletters/weeds/](http://www.landcareresearch.co.nz/publications/newsletters/weeds/)

#### Monitoring the success of your efforts

Feeney C, Greenaway A 2007. ICMP Policy Effectiveness Monitoring to Meet LGA and RMA Requirements. South Pacific Stormwater Conference, May 2007

The Forest Monitoring and Assessment Kit  
[www.formak.co.nz/](http://www.formak.co.nz/)

New Zealand Biodiversity Recording Network (NZBRN) –  
[www.nzbrn.org.nz](http://www.nzbrn.org.nz)

Quality Planning and Monitoring  
[www.qualityplanning.org.nz/monitoring/index.php](http://www.qualityplanning.org.nz/monitoring/index.php)

American Bird Conservancy's Cats Indoors  
[www.abcbirds.org/cats/catsindoors.htm](http://www.abcbirds.org/cats/catsindoors.htm)

Attracting lizards to gardens in Canterbury  
[www.doc.govt.nz/templates/page.aspx?id=33127](http://www.doc.govt.nz/templates/page.aspx?id=33127)

Backyard Wildlife Habitat™ Program (National Wildlife Federation – USA)  
[www.nwf.org/backyardwildlifehabitat/](http://www.nwf.org/backyardwildlifehabitat/)

Florida yards and neighborhoods (University of Florida – IFAS Extension)  
<http://iucncycad.ifas.ufl.edu/fyn/>

Urban Habitat Journal (online)  
[www.urbanhabitats.org](http://www.urbanhabitats.org)

Michael C, Thomas S, Bradley S, McCutcheon H 2007. Reducing the rate of predation on wildlife by pet cats: The efficacy and practicability of collar-mounted pounce protectors. *Biological Conservation* 137: 341–48

## Appendix A: Harmony community covenants and restrictions (CCRs)

HARMONY, FLORIDA

COMMUNITY COVENANTS AND RESTRICTIONS (CCRs)  
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JULY 2001

Prepared by Maggie Brasted, Margaret Baird, & John Hadidian  
Wildlife and Habitat Protection, The Humane Society of the United States  
Reviewed by Mark Hostetler, Associate Prof., University of Florida and Val Beasley, Prof.,  
Department of Veterinary Bioscience, UIUC

The use of the term 'Association' is provisional, pending determination of what oversight and authority will be vested in the community's various organisational groupings.

### SECTION 1: STATEMENT OF GENERAL INTENT

These Community Covenants and Restrictions (CCRs) provide a framework for humans and animals in Harmony to interact in peaceful coexistence with one another, with respect for all life and the land that sustains it.

This section concerns wildlife and the environment, both natural and human-built. These restrictions and recommendations are based on this principle: Wild animals are treasured members of the Harmony community. The unique organising concept of this community requires taking its nonhuman members into account. Promoting the bonds between people and all animals, safeguarding the welfare of animals within the community now and in the future, and serving as a model to other communities for the humane treatment of all animals are the guiding principles of Harmony.

### HARMONY AND ITS ENVIRONMENT

The Harmony concept blends natural and human-built environments in ways that enhance the relationship between humans and animals and maximises the benefits of their peaceful coexistence. While retaining natural areas, Harmony is part of a human-dominated landscape where human actions profoundly and determinably affect the welfare of wild animals. As much as possible in this context, these CCRs articulate a philosophy to allow natural elements to persist unimpeded by humans and to minimise the conditions and circumstances that lead to conflict between humans and wildlife. Harmony's stewardship concept involves balancing a hands-off and hands-on approach.

These CCRs cannot anticipate all aspects of current and future relationships among humans and animals at Harmony. Therefore, these guiding principles and recommended approaches are intended to be dynamic and open-ended to allow the community to explore and adopt new and better conflict resolution strategies, landscape management schemes, environmental management techniques, and practical approaches to maintaining biotic integrity. Harmony must begin with a humane concept for its relationship with wild animals and continue to define and redefine that concept within the context of our larger society as well as in Harmony. An unchanging belief that wild animals deserve respect and should be free of human interference and allowed to interact with humans on their terms will guide this evolving definition process.

In relation to wildlife and to the environment in which they live, the goals of the Harmony community are:

- To promote an understanding of how connected humans are to wildlife and to the surrounding environment.

- To foster tolerance, respect, and understanding of all living things.
- To provide opportunities for Harmony residents to view, hear, and interact with local floral and fauna in an ecologically and environmentally friendly way.
- To create and provide educational activities which will foster a community-wide land ethic and promote future land stewardship.

**To meet these goals, the following sections detail activities that are regulated, prohibited, or encouraged on a community-wide basis.**

## **SECTION 2: TREATMENT OF WILD ANIMALS**

This section applies to human treatment of all wild animals anywhere within Harmony on both private and common property.

**Hunting and Trapping.** Recreational and/or commercial hunting and recreational and/or commercial trapping of any animal are prohibited.

**Attracting and Taming Wildlife.** Taming or making pets of wild animals is prohibited. Young wild animals found or acquired cannot be kept and reared, but must be surrendered to professional rehabilitative care. Free-roaming acclimated and partly habituated wild animals that come and go at will are accepted. Keeping a native wild animal in confinement as a captive is prohibited.

Homeowners are encouraged to provide habitat that offers cover, water, and food for wildlife. Native vegetation that provides cover and food should be the first step that homeowners take to attract wildlife. Supplemental provisions, such as bird feeders and bird/bat boxes, are also allowed to attract wildlife. Nesting and sheltering boxes (such as birdhouses, bat houses, duck boxes, snake boxes, and toad abodes) are allowed and encouraged, but may be subject to limitations in type and number at the discretion of the Association.

Artificial shelters and nesting boxes shall be maintained in good repair and not placed or distributed so as to create conflicts by harboring non-native species or attracting wildlife in such numbers as to be in conflict with humans. Nest boxes shall be constructed so that they can be cleaned and disinfected at least annually.

Garden ponds and birdbaths are allowed and encouraged but must be maintained in good order to prevent the proliferation of noxious insects (such as mosquitoes), toxigenic blue-green algae, bacterial pathogens, or wildlife that could present a problem for people if present in such numbers or places where conflict would occur. Residents are encouraged to visit the University of Florida's Wildlife Extension Web site at [www.wec.ufl.edu/extension](http://www.wec.ufl.edu/extension) for information on these topics.

**Killing or Harming Wildlife.** Wild animals shall not be purposefully injured. Under some conditions, aversive conditioning (training animals to avoid a conflict situation through the use of unpleasant stimuli) may be used as part of a nuisance control program but never in such a way as to cause or sustain suffering of the animal.

Wild animals may be humanely killed to relieve their suffering due to critical injury or illness. The recommended means by which this should be accomplished is euthanasia administered according to veterinary medical standards as established by the American Veterinary Medical Association (AVMA) in their most current guidelines, or other guidelines that have been sanctioned by The Humane Society of the United States (HSUS). Situations of extreme emergency in which human safety or the immediate relief of animal suffering is at issue could warrant exceptions to this requirement.

Control of commensal rodents (rats and mice) where federal, state, or local regulation and standards rule; where human health and safety concerns are threatened; and to limit the growth and spread of a population due to human causes could also warrant exceptions to this requirement. Lethal control of commensal rodents may be conducted by homeowners or registered pesticide applicators, but must be done in strict accordance to Association guidelines and state laws. The use of glueboard traps under any circumstances is expressly prohibited.

**Feeding Wildlife.** Feeding wild mammals, except squirrels and chipmunks, and feeding wild birds, except songbirds and hummingbirds, is prohibited except on an emergency basis as determined by the Association.

Feeding any wildlife when this activity places wildlife at risk is prohibited. Wildlife may be placed at risk by feeding that habituates animals to human, resulting in diminution of animals' fear or normal caution around humans, by abnormally concentrating animals, by increasing risk of contact between wild animals, humans or pets, and other similar situations.

Wildlife may not be indirectly fed by leaving food out for companion animals.

Feeding wild songbirds and hummingbirds is allowed in moderation. Feeding must not lead to conflicts between animals and humans. The Association may recommend proper foods and feeding schedules. The Association may also suspend all bird feeding during any period of increased nuisance wildlife activity. Bird and squirrel feeders should be limited in type and number. Feeders and human-supplied water sources (including birdbaths) shall be kept clean so that disease is not transmitted. Feeders should be protected from 'raiding' by mammals such as raccoons.

**Wildlife Conflicts.** Resolutions to conflict between humans and wild animals shall first be attempted using non-lethal means, except under extreme and immediate circumstances where human safety or the safety of a companion animal is imminently threatened.

Wildlife control, including nonlethal actions, shall not be conducted simply because a homeowner considers the mere presence of a wild animal to be a 'pest' or 'nuisance.'

The approach to wildlife conflict resolution shall follow a series of steps.

1. The conflict is identified,
2. The species causing it is determined and, if possible, the individual animal is identified,
3. Methods to resolve the conflict ranging from least to most invasive and injurious are identified, and
4. An action plan that ensures the least injurious and invasive approach suitable is evaluated and undertaken before other measures are considered.

Preferably, human-wildlife conflicts should be resolved by changing human practices (such as trash management and securing stored food), modifying habitats (changing plantings or managing landscapes), and/or structural modifications (fencing or other methods to exclude animals). Whenever practicable, the cause of human-wildlife conflict shall be sought and the conditions or circumstances that led to the conflict shall be removed.

**Controlling Wildlife Populations.** Circumstances may arise where the community has evaluated a conflict situation and agreed to the need to intervene in and control a local population of wild animals (not merely an individual wild animal or small number of wild animals). Substantial and significant need must be demonstrated for human intervention to be considered. Alternatives to control including altering human practices (such as waste handling and landscaping) and methods to exclude or repel animals should be undertaken before control measures are considered. Control measures must be undertaken through a wildlife management plan that carefully evaluates the best methods for controlling the specific species of concern and seeks the most humane long-term solution. Plans that require multiple control measures should also include long-term strategies to prevent the recurrence of the need for control measures. Control measures may include humane animal capture and relocation to other natural habitats on the property or as allowed by state permitting authorities, reproductive intervention (such as immunocontraception for mammals or egg addling for birds), and other measures reviewed and agreed to be humane by the association.

**Nests and Dens.** Nests of wild birds shall not be taken, moved or interfered with in any manner as stipulated under applicable state and federal law.

No wild animal den or nest of unprotected bird species may be disturbed, moved, or altered except as part of a planned conflict abatement program (described under Wildlife Conflict or Controlling Wildlife Populations), or under compelling circumstances of human health, safety, or security needs.

Young shall not be taken or moved from dens or nests but allowed to mature until they naturally disperse, except where the conditions listed above merit more urgent response. In these circumstances, the family integrity should be maintained by methods to prevent orphaning.

### **SECTION 3: ENVIRONMENTAL MANAGEMENT**

This section applies to activities anywhere within Harmony on both private and common property.

**Use of Chemicals.** The use of avicides (chemicals registered to kill birds) and predacides (chemicals registered to kill predatory animals) is prohibited.

Chemicals to control plants (herbicides), insects (pesticides), commensal rodents (rodenticides), and any other chemical plant and pest control methods must be used only within the context of an Integrated Pest Management (IPM) approach.

This does not apply to materials generally available for non-commercial household use. Chemicals employed shall not harm wildlife when used according to label. An emphasis shall be placed on the use of products or practices that are classified as 'best management' or 'least toxic' by responsible oversight organisations. Acceptable oversight organisations include the Bio-Integral Resource Center (BIRC), P.O. Box 7414, Berkeley, CA 94707; the Northwest Coalition for Alternatives to Pesticides (NCAP), P.O. Box 1393, Eugene, OR 97440-1395; Pesticide Action Network North America (PANNA), 49 Powell St. #500, San Francisco, CA 94102; or their successor organisations that have the same goal of promoting least harmful pest control methods, that have an established record of promoting alternatives to chemical pesticides, and that are not funded by the chemical or agriculture industry. Minimal chemical spraying or application may be done to kill or eradicate invasive plants and where the spraying or application will not impact water quality including affecting an aquifer, watershed, creek, spring, or septic system. To control insects, biological controls (e.g. lady beetles and aphid control) and alternative control methods, such as soap and water should be attempted before resorting to chemical controls.

**Landscaping/Tree Removal.** Planting or maintaining known invasive, non-native plants is prohibited.

Additionally, plants must not have an invasive life strategy that could potentially lead to their spread outside of the homeowner's property. While non-native plants that are not invasive are allowed they are discouraged because they take more fertiliser and pesticides and many Florida wildlife species cannot utilise such exotic plants. For these reasons native plants are encouraged as are plants and landscaping needing minimal human maintenance such as irrigation and chemical inputs.

Removing or thinning trees, branches, and/or deadwood is allowed as property maintenance and to eliminate or alleviate a safety hazard to humans or property. However, removal or thinning must use then-applicable best methods for timing and techniques to least damage or interfere with wildlife and wildlife habitat. Whenever and wherever possible, dead and dying trees (snags) should be left standing as wildlife habitat and maintained to avoid any hazard that could potentially imperil people or property. Whenever possible, any removed trees or branches (other than non-native, invasive, infected, or diseased trees) should be left on the ground at or near the area from which they were removed to decompose naturally or moved to designated common areas to enhance wildlife habitat.

**Fences and Plant Barriers.** Fencing and landscape elements (such as hedges or plant barriers) should not impede wildlife mobility. However, fences and other barriers placed to exclude animals from gardens or other places where they are or reasonably may be expected to be in conflict with humans (for example, deer fencing to protect ornamental plants or vegetables from browsing) are acceptable. No fences and barriers should present a threat of injury to wildlife due to design, construction, or lack of proper maintenance. No barbed wire or hog wire fences shall be used.

**Mowing.** Mowing timing and equipment shall pose a minimal threat to wildlife. As conditions permit, mowing should be performed in the middle of the day rather than early morning or late afternoon. Residential mowers should preferably be manual or electric-powered and recycle cut material (mulching). Mowers should be set to mow lawn area at a height of no less than four inches. Because

lawns are exotic vegetation and essentially are not used by local wildlife species, homeowners are encouraged to reduced the total amount of turf and plant native vegetation.

**Waste and Trash Management.** Except for the activities of the Developer or its designees during the construction or development or as necessary for reasonable and necessary repairs or property maintenance, no trash burning and no accumulation or storage of litter, lumber, scrap metals, refuse, bulk materials, waste, new or used building materials, or trash of any other kind shall be permitted. This provision does not apply to brush piles, snags, coarse woody debris, and similar material placed and/or allowed to remain as wildlife habitat.

Trash containers shall be of approved design and construction that minimises wildlife access. They shall be maintained and used in a manner that does not allow their contents to attract or be accessible to wild or domestic animals, including having lids secured and containers without holes. All trash stored or placed outside for collection must be in an approved trash container. Unsecured trash in bags or open containers is prohibited.

Composting of household and kitchen refuse will be limited to organic matter that does not attract or entice wild animals. Specifically, no animal products or refuse shall be composted outdoors.

All food containers should be rinsed to remove food remnants and odors before disposal or recycling. Plastic food containers (for example yogurt, peanut butter, and others) should also be cut up and/or crushed and each ring in plastic six-pack carriers (and similar packaging) should be cut apart before disposal or recycling. This prevents animals from becoming entrapped by the necks of containers when they try to get food residue. Even when these containers are properly disposed, some can become accidentally separated from the properly handled waste and pose a hazard to wildlife.

Garden and yard refuse should be recycled by composting or similar uses on site whenever possible. This refuse may also be taken to an approved community collection area or designated common area as described under Landscape/Tree Removal. No yard or garden refuse may be placed in other natural areas.

**Lighting and Windows.** Outdoor lighting shall illuminate towards the ground and shall, to the maximum extent practicable, shield light from emitting upwards towards the open sky or surrounding natural areas. Use of yellow lights is preferred because they do not attract insects. To the extent practicable and possible, the threat of bird strikes shall be taken into account when determining window positioning and design during construction, modification, or maintenance of structures. During certain times of the year, bird-friendly alterations to windows may be required. For example, during bird migration tape or other material may be required to be placed on windows to prevent birds from striking the windows.

## **SECTION 4: PRESERVED AREA MANAGEMENT**

Designated natural and preserved areas should be primarily for wildlife use and shall be managed and maintained with that purpose in mind. Human recreation in these areas shall be allowed to the extent that it does not significantly conflict with wildlife use. The Association may close or limit human access and activity in these areas temporarily or seasonally. Trails in natural areas shall be of the least intrusive type possible. Access to unplanned ('social') trails may be closed using signs, downed trees limbs, and other natural obstructions to discourage their use and proliferation.

The function of common areas maintained for human and companion animal use will be well advertised to encourage people to use them in preference to natural and preserved areas. A management plan for preserved areas shall be used to stipulate further concerns and restrictions, up to and including microhabitat management and maintenance.

**Fires and Controlled Burning.** Fire shall be considered and used as an appropriate wildlands management tool, but only under a carefully drawn and considered management plan approved by the homeowners' Association and local authorities that minimises the threat of burning to humans, human property, and animals.

**Corridor Maintenance.** Natural corridors connecting natural areas will be maintained to allow wildlife movement and preserve the integrity of the whole natural system. Existing corridors may not be altered beyond routine and accepted maintenance and may not be destroyed without a valid and justified plan approved by the Association.

**Watershed Maintenance.** Construction or land alteration shall not affect the biotic integrity of the lakes and waterways. Disposal or spillage of hazardous materials and chemicals is prohibited. Vegetation management around streams and lakes shall be conducted only under an approved plan based on justifiable need. Such plans shall include provisions to minimise the impacts on wildlife including timing of management activities.

## **Appendix B: Environmental education programme for communities**

**Programme details:** Currently, we are implementing this on-site environmental education programme in several 'green' communities in Central Florida. This programme can be adapted for any community or situation in New Zealand. We have manufactured several prototype kiosks that are of a wood/aluminum construction or of aluminum only and can be painted any colour to suit the community (schematics and design can be provided upon request). The design is geometrically simple and constructed in such a way that panels can be changed during the year.

Full-Colour Exterior Graphic Panels are placed into each kiosk. To date, we have 28 full-colour panels that cover seven themes:

- Water
- Energy
- Wildlife
- Environmental landscaping
- Insects/pollinators
- Lake/lacustrine habitat
- Natural/human history

The kiosk display is dynamic as panels can be switched. Thus, if the sun bleaches a panel or a different natural resource issue presents itself, a new panel can be printed at a minimal cost. The information on each panel can be adapted to any local situation or need (samples can be provided upon request).

The website generally follows the topic themes listed above. The front page is designed as an entry port for a community and is designed to be compatible, in terms of look and feel, with the overall design and flavour of the community. From there, residents can link to various environmental topics and learn more about local resources, issues, and conservation strategies. Again, this is tailored to local information and resources. The brochure functions as a springboard for people to explore the kiosks and website. This brochure generally has four panels (front and back) and covers the above topic themes.

**Implementation:** Overall, a community can implement any combination of kiosks, panels, website, and brochure. For example, a community may decide to build two kiosks and use all 28 panels for these two kiosks. It is recommended that a community uses the kiosks, website, and brochure in combination but in certain instances, a community may want to use the kiosks alone.

**Estimated costs:** Approximate materials and construction costs (US\$) for the signs and panels:

- 24" × 36" all-aluminum Graphic Display Units: \$1,300.00 each
- 24" × 36" single wood pedestal & aluminum frame Graphic Display Units: \$925.00 each
- Printing costs for full-colour exterior graphics (panels): \$80.00 each
- Printing costs for 1000 full-colour brochures: \$800.00

**Production costs:** Production costs are variable depending on the topics, the community, and the amount of site-specific information that is needed for the graphic displays or the website.

For more information about an environmental education package for homeowners, including a website, interpretive signs, and brochure, contact Dr Mark Hostetler 00 1 352 846 0568, [hostetm@ufl.edu](mailto:hostetm@ufl.edu).