Protecting and restoring our natural heritage

A practical guide

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Department of Conservation
Te Papa Atawhai

Protecting and restoring our natural heritage – a practical guide

Mark Davis – freelance ecologist and Dr. Colin Meurk – Landcare Research plant ecologist

Appendix 2 – (*enter the name of your conservancy here*) information provided by (*insert name of conservancy botanist*)

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PREFACE

Over the last twelve years, the Department of Conservation nursery at Motukarara has assisted many restoration projects by producing native plants and providing information. The demand for up to date information on the planning and management of these projects has increased, as more protection and restoration projects have been initiated. This guide aims to provide the information that many people are seeking, and was produced from additional conservation awareness funding for green issues in the 2000 Budget, and a contribution from Landcare Research.

By bringing together detailed information and project experiences, this guide will help community groups, local bodies and individuals to initiate projects, and make best use of resources to protect and restore our native plants and ecosystems.

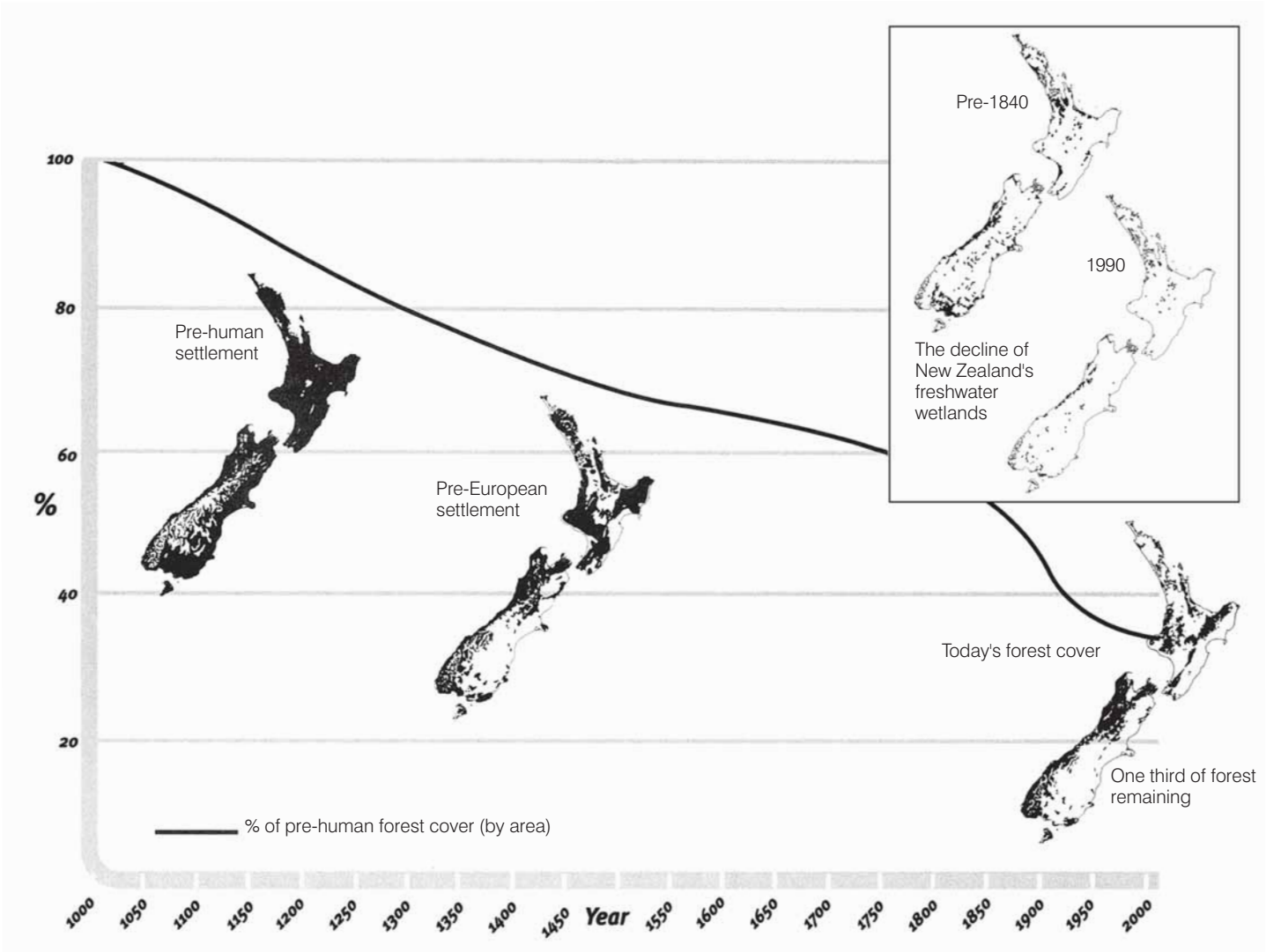
The Department welcomes comments on the guide and any corrections or additional information. These will be collated and considered in future revisions.

Duncan Valley, Mackenzie Country – tarn, shrubland, tall tussock and scree communities.

CONTENTS

1. Introduction

New Zealand is known for its high percentage of endemic plant and animal species (those found only here). As a result of human settlement, many of these endemic species have already been lost. Of those remaining, many are threatened. Native plant communities often survive only as isolated remnants, particularly in landscapes modified by agricultural use or human settlement. Ecological processes in these remnants have often been disrupted, so that their long-term viability in under threat.



Many of these remnant ecosystems are not well represented in our system of Protected Natural Areas (natural areas that are legally protected). It is not simple to protect, manage and restore remnant native ecosystems, particularly alongside farmland and settlements. Anyone tackling such a project can achieve a lot, and the results will contribute to preserving New Zealand's biodiversity.

MANAGING REMNANT ECOSYSTEMS

This guidebook provides information on protection, management and restoration of native ecosystems – why it is needed, how it can be done and where you can obtain further information. The material is presented in the order in which you need to proceed for any management or restoration project. At the end of some major sections "Further reading" lists a number of the more approachable and relevant references. Try public or university libraries, or the people or organisations that produced the information. You may be able to buy some of these reports or books.

Native animals are an integral part of ecosystems and restoration ecology, but detailed attention to them is beyond the scope of this guidebook. It focuses on the plant communities that provide their habitat. Similarly, the guidebook cannot provide detailed information and examples for the whole country, and you should seek information about your own region where appropriate, e.g., local case studies and resources available.

LANDSCAPE RESTORATION

To sustain native biodiversity, we need to maintain ecological systems that connect natural areas throughout the wider landscape (Park 2000). Restored areas provide stepping stones or islands of biodiversity, reducing the distances between natural ecosystems. Corridors or linkages between remnant or restored ecosystems are important for dispersal, migration and genetic exchange, as well as nutrient transport and energy flow. In highly modified areas many of these linkages have been lost and need to be restored.

Landscape restoration looks beyond individual remnants and restoration projects. It involves protecting native remnants, enhancing damaged or unbuffered remnants, and restoring connections between them. Examples of areas that can provide such linkages include roadside remnants, hedgerows, shelterbelts, woodlots, water races, rivers and streams (Meurk and Swaffield 2000). Waterways are particularly valuable, as they connect rural and urban areas and often extend between uplands and the sea. In urban settings, recreational areas can be used to provide linkages with natural areas. These are all areas that you should consider as suitable for restoration projects.

For landscape restoration to be effective, co-ordination between landowners, voluntary groups, protection agencies and councils is required. Your project will form part of this essential network.

An example of a landscape where human and natural elements sit comfortably with each other is shown in figure 1B.

Figure 1A - before restoration

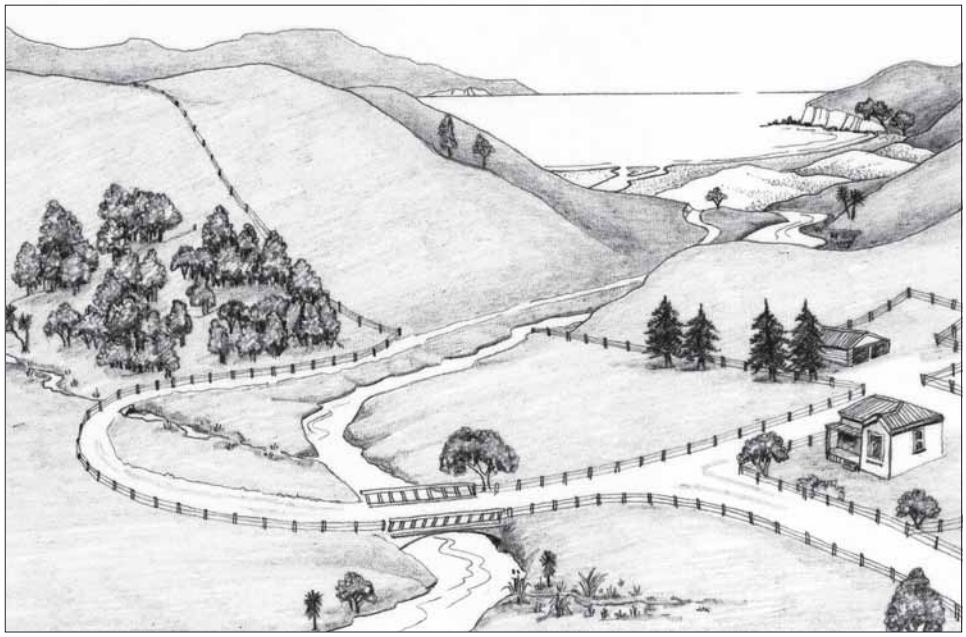
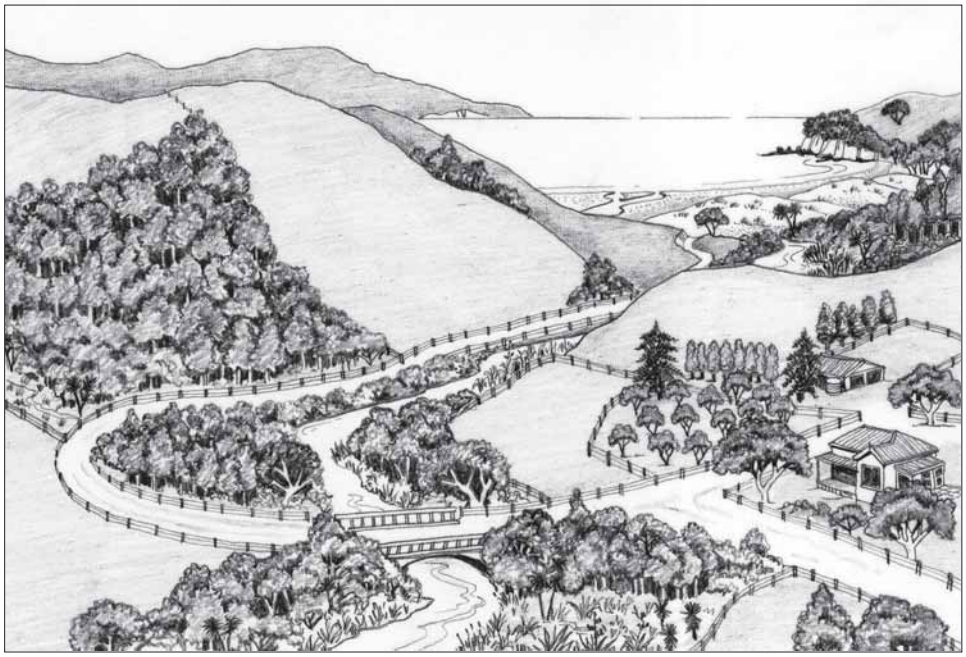


Figure 1B - after restoration



Further reading

The New Zealand biodiversity strategy. Department of Conservation and Ministry for the Environment 2000. *[Book - provides some background about the importance and state of NZ's biodiversity, and approaches to managing it]*

The New Zealand protected natural areas programme. A scientific focus. Technical Advisory Group, PNA Programme 1986. *[Book – outlines threats to natural areas, the unrepresentative nature of our protected natural areas and the contribution of the PNAP to nature conservation]*

The state of New Zealand's environment. Ministry for the Environment 1997. *[Book – contains detailed information about our waters, land and biodiversity]*

2. Legal Protection

PROTECTION OPTIONS

If you leave the protection of your native ecosystem to the goodwill of future owners, they could undo all your efforts. Legal protection ensures that your conservation achievements will continue, usually in perpetuity. It also means you can ask for funding from agencies like the Nature Heritage Fund, Queen Elizabeth II National Trust, local authorities or Ngā Whenua Rāhui (for Māori land) to help with survey, legal and fencing costs.

To obtain legal protection, you will need to define the area by survey, decide on what sort of protection you want, and detail how the ecosystem will be managed to maintain or improve its values. You should seek formal protection early in the project so that you do not waste time, enthusiasm and money.

A number of legal protection options can be tailored to suit your wishes as the landholder:

Selling or gifting land

You can sell or gift land to a variety of agencies, organisations or trusts for protection purposes. The buyer usually meets some or all of the transaction costs. An area bought or gifted under the Reserves Act will be given a reserve classification. It then needs to be managed for the primary purpose stated in that classification. This will involve producing a management plan, which needs public input.

Conservation covenants

You can enter into a covenant with the Department of Conservation, Queen Elizabeth II National Trust or local authorities. A covenant is a legal agreement between the landholder and the covenanting agency about how the area's natural values will be protected (e.g., where fencing is needed and whether public access will be allowed). As the landholder, you retain ownership and the covenant is registered against the title, usually in perpetuity. It is binding on future owners. Owners of Māori land can place areas under a Ngā Whenua Rāhui kawenata. Although this may be for protection in perpetuity, the terms and conditions can be reviewed every generation (not less than 25 years).

Both parties manage covenanted land in accordance with the agreement, and the covenanting agency may provide specialist advice. Financial assistance may be available to the landholder, usually for survey, legal and fencing costs. As the landholder, you may also apply to the local authority for rates relief.

The QE II covenant of Brian and Chris Rance at Otatara, Invercargill. This restored wetland grades into densely planted shrubland, buffering the remnant tôtara forest beyond. The owners have also established a nursery that produces native plants for community restoration projects and propagates threatened species.

Monitoring is usually needed to assess the effectiveness of management actions and changes to protected values. Either you or the covenant agency can do the monitoring in accordance with the agreement.

Protected private land agreements

You can make a protected private land agreement with the Department of Conservation. As the landholder, you retain ownership, and the agreement is recorded on the title by gazette notice.

Land exchange

You can exchange land where it is of interest to both parties. You may have costs related to equality of exchange, survey and legal requirements. Local authorities undertaking land exchange under section 15 of the Reserves Act, must seek public comment.

Management agreements

Management agreements between the Department of Conservation and a landholder under section 29 of the Conservation Act are not registered against the title and do not bind future owners. These are temporary agreements that keep your management options open until you reach a final agreement for improved protection.

Esplanade reserves

Esplanade reserves can be used to provide voluntary riparian or ecological protection quite separate from the subdivision requirements of the Resource Management Act. Such reserves are set aside under the Reserves Act as local purpose (esplanade reserves) through a local authority or the Department of Conservation. They can be of various widths.

FUNDING SOURCES AND CONTACTS

You can seek funding towards the protection of a remnant ecosystem. Funding may be provided for purchase, survey, legal and fencing costs, or it may be provided in the form of rates relief, special funds or grants. Note that as a funding condition, the Nature Heritage Fund and Ngā Whenua Rāhui both require legal protection and an outline of proposed management. Ngā Whenua Rāhui is only available to owners of Māori land.

Landcare Research runs the project EBEX 21, promoting protection and restoration by landowners and businesses wishing to offset the environmental impacts of their activities (see Services and Businesses, at http://www.landcare.cri.nz).

Table 1. Agencies that implement legal protection, offer funding assistance or provide advice about the management of protected areas

Agency	Offers legal protection	Possible funding source	Offers management advice
Department of Conservation	Y	Y	Y
Nature Heritage Fund	N	Y	N
Nga Whenua Rahui	N	Y	N
QEII National Trust	Y	Y	Y
Lottery Grants Board	N	Y	N
Local Authorities	Y	Y	Y
Landcare Research	N	Y	Y

Table 2. Main contacts for information or advice about legal protection and management of protected areas

Department of Conservation - Conservancy and local Area Offices Web site: http://www.doc.govt.nz	QEII National Trust P.O. Box 3341, Wellington Freephone 0508-732-878
Nga Whenua Rahui P.O. Box 10420, Wellington Phone (04) 4710-726 Web site: http://www.doc.govt.nz	Federated Farmers of New Zealand P.O. Box 715, Wellington Phone (04) 473-7269
Fish and Game Councils Regional Offices	New Zealand Landcare Trust P.O. Box 16-269 Christchurch Phone (03) 349-2630
Regional Councils	District/City Councils
Native Forests Restoration Trust P.O. Box 80-007, Green Bay Auckland 7 Phone (09) 636 7564	Ducks Unlimited P.O. Box 9795, Auckland Phone (09) 625 9002
New Zealand Ecological Restoration Network P.O. Box 9000, Christchurch Web site: http://www.bush.org.nz (local contacts through web site).	

Further reading

Conservation covenants. A guide to assist local authorities to protect and conserve waterways, wetlands and other natural areas. Christchurch City Council 1998. *[Booklet – describes different protection mechanisms, the purpose of covenants and how they work, legal aspects, management and provides two case studies. First copy free per local authority]*

Nature Heritage Fund (undated). *[Pamphlet – outlines the purpose of the fund, different means of protection, funding criteria, application funding dates and who to contact]*

Ngā Whenua Rāhui (undated). *[Pamphlet – outlines the purpose of Ngā Whenua Rāhui, including the protection and management of Māori-owned land, funding assistance and who to contact]*

Open space covenants. Frequently asked questions. Queen Elizabeth II National Trust 2000. *[Pamphlet – outlines key aspects of covenants, how they are arranged and possible rates relief]*

Voluntary protection of nature on private property. Your land your choices. Department of Conservation (undated). *[Pamphlet – outlines protection options, funding sources, incentives and organisations to contact for further information]*

3. Key steps to effective management

In this guidebook, "management" means any action taken to prevent or reduce further degradation of native ecosystems. The purpose of management is to encourage natural processes (like plant regeneration and succession) and control weeds and pests that interfere with these processes. You should nearly always protect and manage natural ecosystems (**sections 3 & 4**) as a priority, before attempting restoration (**sections 5 to 10**).

MANAGEMENT PLANS

A management plan (or checklist) helps ensure you address important issues and follow a clear course of action. You should prepare a detailed management plan for large protected areas or those that are publicly funded. For others a simple checklist may be adequate. If the area is to be legally protected, you may have to follow a formal process.

Ensure that your management plan includes the following actions. It should:

- Describe the remnant, its natural resources, and their importance (e.g., main communities and species, landforms and water bodies).
- Outline any management issues or threats.
- State the goals or aims of protection. These should be realistic and straightforward, e.g. *Protect the (specified) forest remnant and ensure it is self-sustaining.*
- State objectives that identify what management results are sought for specific issues or threats, e.g. *Identify the factors limiting natural regeneration, and take action to restore this process.*
- Detail methods that describe how the objectives will be tackled and in what time frame, e.g. *Erect post and wire fences to exclude stock*, and *hand removal of weeds within 6 months.*
- Specify monitoring methods for assessing the effects of management actions or natural change.
- Indicate how you will adapt management actions in response to assessment.

SITE ASSESSMENT

Clarifying an area's ecological values and importance will help justify its protection, and provide background information for use in your management plan. It will also help you identify threats to the ecosystem, and where there are restoration needs. Depending on the size or complexity of the ecosystem and the level of protection/ funding being sought, you may need specialist advice or assistance.

Your site assessment should:

- Describe the main plant/animal communities, and their condition.
- List the main and any threatened native plants and animals.
- Describe the main landforms, such as river terraces, fans, ridges and slopes.
- Identify water bodies and drainage patterns, including wetlands, creeks and damp areas.
- Identify factors affecting the ecosystem, such as aspect, wind exposure, frost, drains, weeds, animal pests and grazing.

WEED CONTROL

Although many introduced plants do not cause problems in natural ecosystems, invasive weeds can limit the regeneration or retention of native plants and animals. Weeds may be herbs, shrubs, vines or trees. They typically invade open or disturbed sites, which are often found in remnant ecosystems. You will nearly always need to control weeds, as they compete for light, space, moisture and nutrients. You have a legislative obligation to control or eradicate weeds identified in your local Regional Pest Management Strategy.

Key management guidelines

- Prepare a weed management strategy so that weed control is done logically and efficiently.
- Assess whether weeds really are a problem, or whether attempted control will only make matters worse.
- Identify and eliminate weed sources within remnants and from adjacent lands, and reduce open areas that could be invaded by weeds (Porteous 1993).
- Tackle weed control promptly, or the task may get out of hand ('one years seeding, seven years weeding').
- Avoid over-clearing weeds where control could cause disturbance, weed re-establishment or openings for new weeds, e.g., willow removal resulting in blackberry spread.
- Minimise the use of herbicides by using other weed control methods as much as possible.

Weed control methods

- **Shading** - dense planting shades out some weeds and limits their establishment.
- **Hand weeding** - labour intensive, but suitable for specific weeds, fragile sites or low levels of infestation. Hard to kill weeds should be removed from the site (Porteous 1993).
- **Ring barking** - woody weeds with large stems or trunks (Porteous 1993)
- **Mechanical weeding** - e.g. the use of weedeaters and rotary slashers.
- **Controlled grazing** - based on carefully applied adaptive management.
- **Biocontrol** - introducing biological agents, such as fungi or insects to control specific weeds, e.g. gorse, spider mite.
- **Herbicide use** - applied to cut stumps, sprayed onto leaves, injected into the trunk or applied to frills around a trunk (Porteous 1993).

Caution

Poorly managed weed control is a major cause of native plant death.

- Weedeaters can ring-bark planted trees.
- Grubbing can damage sensitive roots.
- Native plants are sensitive to herbicides, especially podocarps. Spray drift can easily destroy an expensive plant, wasting time, effort, and money.

Inadvertent spray damage to kahikatea is expensive in direct costs, lost time and lowered morale.

ANIMAL PEST CONTROL

Rabbit damaged tussocks and matagouri.

Originally New Zealand had no land-based mammal predators or browsers, but human settlement inroduced domestic stock, game animals, vermin and their predators. Wild animals and animal pests are defined by statute, but they are all termed 'animal pests' in this guidebook. They include mice, rats, stoats, rabbits, hares, goats, pigs, deer, possums, cats and introduced insects such as wasps. All these need controlling as they eat foliage, fruits and seeds, compete with native animals for food (or eat them as food) and alter ecological processes. You have a legislative obligation to control animal pests identified in your local Regional Pest Management Strategy. Sometimes you will need to co-ordinate any control efforts with adjacent landholders. This is particularly important for large sites and often involves working with regional councils, DOC and Landcare groups.

Key management guidelines:

- Prepare an animal pest management strategy, so control is done logically and efficiently.
- Identify which pests are problems, and what control methods should be used.
- Identify possible prey switching that might occur, e.g. increased predation on native birds when rabbit numbers are reduced.
- Undertake control promptly before pest numbers build up.
- Work co-operatively with neighbours and other managers if appropriate.
- Beware of all health, safety and environmental impacts associated with animal control

Animal control methods

- **Poisoning, shooting and trapping** - need to avoid killing non-target species.
- **Fencing** - excludes some animal pests, and can be cost-effective, e.g. rabbit netting.
- **Shields** - to deter possums; **moats** around wetlands - to reduce pest access.
- **Creating less suitable conditions** - such as increasing vegetation cover and moisture to deter rabbits.
- **Biocontrol** - using biological agents to control pests, e.g. parasitoid wasps on wasps.
- **Integrated pest management** - a combination of these methods, often used in special areas subjected to intensive pest control, e.g. DOC's 'mainland islands'.

Excluding stock and wild animals from this mountain beech/tawhai forest in the mid Canterbury foothills has resulted in the regeneration of palatable understorey species.

DOMESTIC STOCK

Domestic stock include sheep, cattle, goats, deer and any other farmed animals. Their impacts include grazing or browsing native vegetation, preventing plant regeneration, altering soil and water nutrient levels, compacting soil and spreading weeds. Stock must be excluded from forests and most other protected areas. However, controlled grazing may be used to maintain biodiversity in some induced shrublands and grasslands (**see section 4**).

Pingao remnant nearly destroyed by cattle.

Stock control methods

- **Fencing** - needs to be appropriate for the type of stock and be regularly maintained.
- **Repellents** - realistically an option only where plants are small, e.g. restoration plantings.
- **Co-operation between adjacent landholders** - can reduce stock access, but no substitute for secure fencing.

Caution

Fences are your only realistic option for excluding stock.

The most elaborate fences, such as those at Karori Wildlife Sanctuary, exclude all land animal pests and stock. A single-strand electric fence may be sufficient to keep cattle out, as long as you check it frequently. Environment Waikato has information about a cheaper predator-proof fence suitable for use by private landowners.

A demonstration section of the predator fence at the Karori sanctuary, Wellington. This elaborate fence even excludes mice and is also able to withstand human sabotage.

BUFFERING

You can establish a buffer zone or area around a remnant and manage it to limit adverse effects from adjacent land uses. Buffers may take the form of a shrubby border, which also provides new habitat and increases local species diversity. Specific benefits include:

- Reducing fire risk.
- Reducing risk of spray damage.
- Protecting forest edges from wind penetration and weed ingress.
- Protecting sensitive plants and animals in the interior.
- Limiting input of sediments and nutrients (particularly in wetlands and riparian areas), and introduced plant seeds.

MONITORING

Monitoring measures the success of a project in terms of its stated goals and objectives. Whatever monitoring methods you use, they should be as simple as possible (Atkinson 1994), standardised and repeatable.

Formal scientific monitoring is appropriate for large-scale, publicly funded projects. Professional advice will ensure a more reliable evaluation and interpretation of habitat changes. For most small projects, it is enough to take photographs from fixed points at the beginning, and then at regular intervals (e.g. annually). Record the date on them, and choose views that will not be grown out.

For more elaborate monitoring you need to use several indicators sensitive to various kinds of change. Indicators that can be measured include:

- Spread or incidence of weeds.
- Damage caused by stock grazing or animal pests.
- Changes in regeneration patterns after fencing.
- Build-up of forest litter.
- Cover of ferns, mosses and lichens, as an indicator of microhabitat development.
- Bird and invertebrate records as indicators of increasing diversity.

Monitoring methods

- Fixed sample plots to measure changes in plant species presence, density and regeneration.
- Photopoints to provide a picture of ecological changes, such as plants regenerating after animal pests have been excluded.
- Fixed sample plots to measure changes in abundance of pests and weeds (trapping, pellet counts, cover and density).
- Standardised observations of bird numbers and species (such as 5-minute counts) or sampling of invertebrates (transects and pitfall traps).

Once you have achieved the initial desired vegetation structure, the simplest measures of sustainability are regeneration and resistance to weeds.

Further reading

An illustrated guide to common weeds of New Zealand. Roy B, Popay I, Champion P, James T and Rahman A 1998. *[Book – photographs and descriptions of a wide variety of weeds. A number of native plants are listed as weeds, but little explanation is given for their selection. We do not think they should be described as weeds]*

Christchurch waterway maintenance plant guide. Weeds, and how to tell them from similar looking plants. McCombs K, Meurk C and Morland K 1999. *[Book, available on request from Christchurch City Council – contains clear photographs and descriptions for easy plant identification]*

Ecology and management of invasive weeds. Williams PA 1997. *[Book – provides in-depth information about weed life forms, dispersal, vegetation succession and weed control]*

Gully restoration guide. A guide to assist in the ecological restoration of Hamilton's gully systems. Wall K and Clarkson B 2001. *[Booklet – a step by step guidebook on gully restoration. Includes a gully profile, information on soils, native plants to use, and weed identification and control]*

Native forest monitoring. A guide for forest owners and managers. Handford P 2000. *[Book – provides detailed information on methods, fieldwork, data analysis, indicators of forest health, and the level of skill and precision needed for the methods used]*

Native forest restoration. A practical guide for landowners. Porteous T 1993. *[Book – comprehensive coverage of managing remnants, with detailed restoration techniques]*

New Zealand's wetlands. A management guide. Buxton R 1991. *[Book – describes different types of wetlands and their functioning, and provides management and restoration guidelines and summaries]*

4. Native ecosystems and their management

This section outlines the main ecosystems you are likely to encounter and the main actions needed to manage them. Many will only be remnants.

Caution

Weed control is critical in all remnant ecosystems. See Appendix 1 for key invasive weeds.

FORESTS AND SHRUBLANDS

Remnant forests and shrublands are often threatened by animal pests, weeds, stock, wind exposure, reduced water supply and physical isolation from similar ecosystems. Management will enhance natural processes such as plant regeneration and succession, reduce wind damage to forests and reduce predation of birds, lizards and invertebrates (e.g. insects, spiders and worms). Successful management will reduce the need for further intervention.

Forest and shrubland

Shrublands are usually a temporary stage in the natural succession to forests, though in harsh environments they may be semi-permanent, e.g., kānuka woodlands in Central Otago, or saltmarsh ribbonwood/mākaka on estuarine margins. Shrublands support many native plants and animals and help buffer other ecosystems. They sometimes provide specialised habitat for threatened plants and animals. Where they do so, it may be appropriate to prevent native shrubland from developing to forest. You will need to seek specialist advice on this as management guidelines are still developing.

Key management actions

- Prevent fires.
- Control animal pests (rabbit control will be essential in dry shrublands).
- Exclude stock by fencing.
- Retain gorse and broom as a nurse crop, in some circumstances (see below).
- Control other weeds, especially around edges or in open patches.
- Undertake restoration planting around edges, in open areas or to provide linkages if needed (**see sections 5 to 10**).

Coastal forest near Kaikoura.

Managing succession through shrub weeds

Shrubland and forest will succeed gorse, broom and other shrub weeds if certain conditions are met. The following material is summarised from McCracken 1993, and applies to eastern South Island conditions.

Native forest can develop through undisturbed gorse, broom and elderberry by natural succession in 10-20 years, though dry sites distant from seed sources will take longer. The shrub weeds initially form a dense canopy that suppresses grasses and weeds, and later protects seedlings and saplings of native plants. This process is a realistic option for marginal grazing land. Little intervention is needed if you follow a "minimum interference management" regime:

- Exclude all domestic and wild animals by fencing or other means.
- Prevent fire, as broom and gorse will prosper most.
- Clear all property boundaries of gorse and broom for a width of at least 10 m, to meet statutory requirements.

Broadleaved evergreen trees, such as ngaio, provide a partial firebreak in Island Bay's gorse-covered hills.

Table 3. Factors affecting succession through gorse and broom.

Key Factors		Score
Rainfall	> 1200 mm (wet)	5
	700 -1200 mm (moderate)	3
	00	5
Aspect/exposure	E/S/W (cool, moist)	
	NW/N/NE (dry, warm)	1
Distance from native seed source	< 2 km (close)	5
	2 - 10 km (moderate)	3
	> 10 km (distant)	1

Total score of 11-15: [moist sites close to seed sources] - high potential for quick succession, with no enrichment planting needed.

Total score of 6 - 10: - good potential for succession; enrichment planting may be needed, but only after the natural process has been given a reasonable trial.

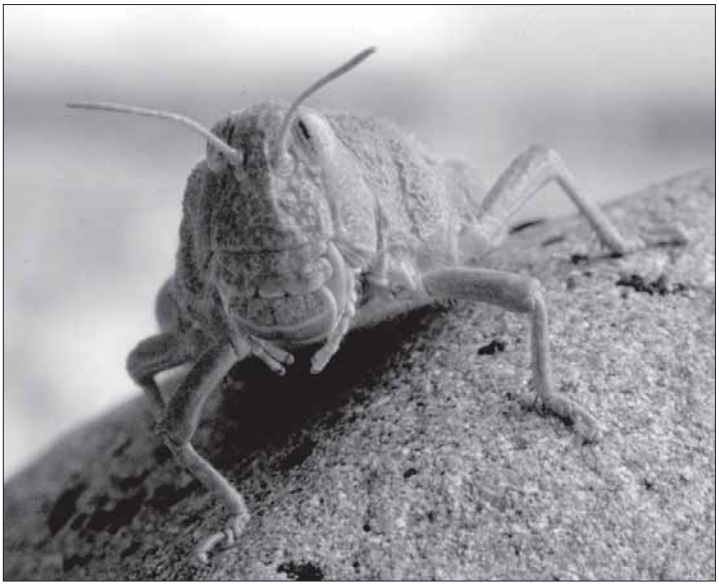
Total score of 3-5: - succession will occur only if seed sources are a moderate distance away, and will be dependent on favourable seasons; enrichment planting may be needed.

The lower the score, the more important it is that grazing or browsing is prevented. The density of gorse and broom affects the rate of succession – as dense stands age, they become more open and move more quickly to succession, especially in the absence of grazing or browsing.

Near the upper natural limit of native trees, you should control all new outbreaks of broom or gorse. This is important, as there may be no remaining native trees to suppress them here. Controlled grazing may provide a holding measure. If a native seed source is nearby, trees like beech/tawai, mountain tōtara and mountain celery pine/toatoa may eventually overtop the shrub weeds.

GRASSLANDS AND HERBFIELDS

Grassland and herbfield communities feature turf grasses, tussocks or broad-leaved herbs. Because many grasslands have been induced by the destruction of forests and shrublands, there is likely to be a natural trend of succession back to woody vegetation. Induced grasslands often support native plants and animals that may not be present or abundant elsewhere. As a result, it may sometimes be appropriate to prevent natural succession to shrubland or forest, e.g., to maintain populations of uncommon species or to retain a tussock landscape.



Brachaspis robustus – New Zealand's largest native grasshopper, which lives only in the Mackenzie Basin.

Management aims to control exotic grasses and weeds, and encourage natural processes. Wilding trees can be a serious problem, especially in mountain grasslands. You should not use fertiliser where many small native plants grow amongst the tussocks, as it favours exotic species. Managing short tussock grasslands is particularly difficult because of widespread exotic grasses and hawkweeds (*Hieracium* spp.). Tall tussock grasslands are less problematic if they are sufficiently dense to shade out exotic grasses and weeds, particularly hawkweeds. Burning to retain tall tussock is problematic, as it favours the spread of weeds and may contribute to soil nutrient losses. Controlled grazing can be used as a management tool, and may help browse-resistant, woody nurse plants like kānuka, to colonise exotic pasture.

Because of the complexities of grassland management, you should seek further information and specialist advice.

Duncan Valley, Mackenzie Country – tall tussock and wetland flushes.

Key management actions

- Graze short tussocklands if competition from ungrazed exotic grasses is a problem, e.g., on fertile soils.
- Exclude stock from mountain and degraded grasslands, or graze infrequently if exotic grasses are only a minor problem.
- Control wilding trees by removing, and painting the stumps with herbicide if necessary.
- Exclude stock from dense or regenerating tall tussocklands (say >20% cover).
- Control rabbits in dry to moderate rainfall areas.
- Exclude oversowing and topdressing, unless a tussock appearance is the main purpose.
- Prevent fires, but seek specialist advice if trying to maintain tall tussockland.

Oversown and topdressed short tussock. Healthy tussocks but few native inter-tussock species remain.

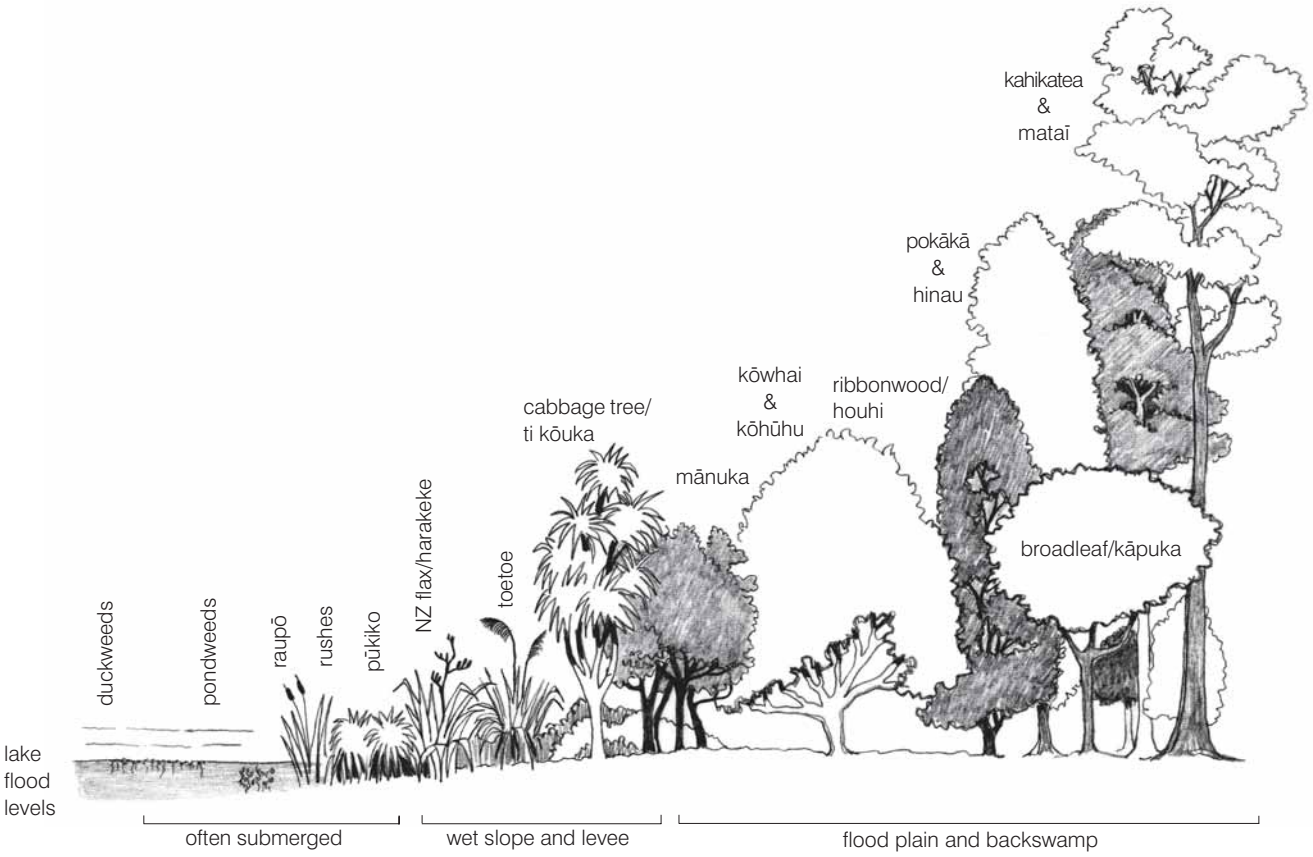
WETLANDS AND RIPARIAN AREAS

Wetlands are permanently or intermittently wet areas characterised by peaty or grey soils, and plants and animals adapted to these conditions. Open water may be absent or only periodically present. Wetlands include coastal lagoons and estuaries, which support plants and animals tolerant of saline or brackish conditions. They provide an essential link between marine and freshwater ecosystems and are vital to the life cycle

Cattle damage to a small creek – the edges are trampled, water quality is reduced and tussocks are heavily browsed.

of many fish, birds and invertebrates. Riparian areas occur alongside waterways and water bodies; they provide valuable habitat for plants and animals, and affect water quality. Wetlands and riparian areas are often degraded by human use. Grazing affects most unprotected wetlands and riparian areas, reducing vegetation stature and density and letting in more light. This makes them vulnerable to drying out and invasion by weeds.

The single most important factor in protecting a wetland is sustaining its water supply. Other management actions aim to exclude stock, reduce weeds, prevent substrate damage and reduce nutrient inputs. You may need to control vehicle use as it can damage faunal habitat, vegetation and substrates. Nesting birds are disturbed by motorboats, which may need to be controlled. If you wish to maintain a mosaic of open water and emergent vegetation, you may need to control raupō as it colonises open water. As a result of management, moisture levels and plant regeneration should increase. It is important to recognise that wetlands tend to dry out through natural processes and be colonised by woody vegetation. For this reason and their inherent complexity, you should seek specialist advice about their management, e.g., grazing to maintain turf communities or bird habitat.



A profile of mature riparian/lakeshore vegetation

If you protect and restore riparian areas, water quality should improve, flood peaks decline and habitat for land and water animals increase. A minimum riparian width of 10 m is recommended on either side of a stream, but you will need larger buffers for rivers, i.e., 20 m plus. The width of a protected riparian area most likely to support self-sustaining native vegetation with minimal maintenance, is 15-20 m (NIWA 2000).

Key management actions

- Improve water supply if necessary, e.g., by blocking or redirecting a drain.
- Exclude stock except in special circumstances.
- Exclude oversowing and topdressing to reduce nutrient input and grazing.
- Control weeds.
- Prevent fires.
- Control animal pests.
- Control human impacts, e.g., motorboat and off-road vehicle use.
- Undertake restoration planting if needed.

COASTAL DUNELANDS AND BANKS

Dunelands close to settlements and farmland are more vulnerable to a range of uses. On these dunelands, historic burning and grazing triggered erosion. The marram grass, tree lupin and pines planted to stabilise the sand then displaced native species such as pīngao and spinifex/kōwhangatara. Native dune vegetation is now less common, and natural dune and bank systems are usually found only in remote locations.

Management aims to reduce vegetation damage from animal pests, stock, weed competition and human over-use. Protection also increases natural plant regeneration and succession, and limits disturbance and predation of native animals, particularly lizards. You may need to undertake restoration planting of communities where native dune-binding plants (spinifex/kōwhangatara, pīngao and sand tussock) have disappeared or are only sparse. This may include blowout sites. You may also need to plant coastal bush and shrubland on reardunes to help remedy their past destruction.

You can fertilise existing depleted stands of foredune sand-binders to boost growth and cover without significantly increasing weed growth. This is far cheaper than planting programmes (D Bergin, pers. comm.). You should only fertilise where plants are not vigorous and where you want vegetation cover to spread onto bare sand. Use only small amounts of broadcast fertiliser, say 50 kg N/ha, 2-3 times a year, as other environmental effects such as those on invertebrates and microbes are unknown (D Bergin, pers. comm.). You should monitor plant responses and stop fertiliser additions once plant cover or vigour increases.

Kaitorete Spit – the largest pingao population in the country.

Key management actions

- Exclude stock.
- Control weeds.
- Exclude vehicle use, including motorbikes and off-road vehicles.
- Limit walking access across dunes if necessary.
- Control animal pests.
- Prevent fires.
- Replant lost communities.

Further reading

Bowenvale vegetation, assessment and management recommendations. Meurk CD and Wilson HD 1990. *[Booklet – a short report that includes discussion of the grazing of short tussock grasslands, plant succession and nurse plants]*

Canterbury region wetlands. Preliminary report and inventory. Davis M 1999. *[Book, available from Environment Canterbury – includes general discussions of wetland functioning, threats and restoration needs]*

Christchurch waterway maintenance plant guide. Weeds, and how to tell them from similar looking plants. McCombs K, Meurk C and Morland K 1999. *[Book - available on request from Christchurch City Council – contains clear photographs and descriptions for easy plant identification]*

Coastal sand dunes, form and function. Hesp PA 2000. *[Booklet – describes the different types of dunes, their functioning and dynamics, erosions issues and the importance of coastal dunes]*

Managing riparian zones: a contribution to protecting New Zealand's rivers and streams. Collier KJ, Cooper AB, Davies-Colley RJ, Rutherford JC, Smith CM and Williamson RB 1995. *[Two books – volume 1 outlines why riparian zones are*

important, and the natural processes affecting rivers and streams; volume 2 provides guidelines for specific problems like bank instability, grazing and increasing habitat diversity. ***Note*** *– for ecological restoration, we recommend the use of cabbage trees, NZ flax, toetoe, kōhūhu (Pittosporum tenuifolium), karamū (Coprosma robusta) and lowland ribbonwood for erosion control, rather than exotic trees]*

Managing waterways on farms: a guide to sustainable water and riparian management in rural New Zealand (draft). Ministry for the Environment 2000. *[Book – outlines what a healthy waterway is, the impacts of agriculture and forestry, managing problems and restoring riparian vegetation; includes 16 case studies.* ***Note*** *– for ecological restoration, we recommend the use of cabbage trees, NZ flax, toetoe, kōhūhu (Pittosporum tenuifolium), karamū (Coprosma robusta) and lowland ribbonwood for erosion control, rather than exotic trees]*

Native forest restoration. A practical guide for landowners. Porteous T 1993. *[Book – comprehensive coverage of managing remnants, with detailed restoration techniques]*

New Zealand's wetlands. A management guide. Buxton R 1991. *[Book – describes different types of wetlands and their functioning, and provides management and restoration guidelines and summaries]*

Rehabilitation of coastal foredunes in New Zealand using native sand-binding species. Bergin DO and Kimberley MO 1999. *[Book, available from DOC Science Publications – covers pīngao, sand tussock and spinifex, which are separately addressed in other references by Bergin]*

Review of information on riparian buffer widths necessary to support sustainable vegetation and meet aquatic functions. National Institute of Water and Atmospheric Research 2000. *[Book – site visits were made and native vegetation was considered to be more sustainable over the long term than exotic vegetation]*

Riparian zones. A guide to the protection of Canterbury's rivers, streams and wetlands. Canterbury Regional Council (undated[3]). *[Pamphlet - available from Environment Canterbury – outlines erosion control, habitat values, pollution control and riparian planting.* ***Note*** *– for ecological restoration, we recommend the use of cabbage trees, NZ flax, toetoe, kōhūhu (Pittosporum tenuifolium), karamū (Coprosma robusta) and lowland ribbonwood for erosion control, rather than exotic trees]*

The natural succession option. A strategy to replace gorse and broom on Canterbury's marginal pastoral lands with native forest. Canterbury Regional Council (undated[2]). *[Pamphlet, available from Environment Canterbury – outlines natural succession by native woody species, and factors affecting succession potential. It is based on the booklet by McCracken 1993, which is straightforward and provides more detail]*

Wetland plants in New Zealand. Johnson PN and Brooke PA 1989. *[Book – a detailed plant identification text, with a discussion of wetland habitats and vegetation]*

5. Initiating a restoration project

CONTRIBUTING TO CONSERVATION

In many parts of the country, restoration planting is your last and only option for repairing or rebuilding damaged native communities so that they will become self-sustaining. It involves removing damaging agents, such as weeds and pests; reinstating lost components, such as native plants and animals; and encouraging natural processes, such as plant succession.

In its narrowest sense, restoration planting is modelled on a previous baseline – usually the pre-European vegetation of that site. However, we cannot know the exact composition or successional stage of vegetation 160 years ago. It is more realistic to restore key elements of the ecosystem (especially those unlikely to get there naturally), then let natural processes rebuild themselves and species regenerate. In this way, restoration is more about processes than a snapshot of past vegetation – it is more like 'kick-starting a motor'.

Restoration plantings contribute to nature conservation, but they are second-best and far more expensive than protection. Restoration is no substitute for protecting natural ecosystems, as a restored system can never be as authentic as a natural system. We simply do not know enough about the complexity of ecosystems, nor can we mimic evolutionary history.

Planting has its pitfalls

If you have a choice, remember that in natural succession:

- Nature puts plants in the right places.
- Self-established plants are normally more healthy.
- There is less work for managers, and it is less expensive.
- The process and end results are more scientifically interesting (akin to a natural forest, rather than a garden).

This guidebook does not deal with the related concepts of rehabilitation and revegetation. These aim to re-establish a lost plant cover (not necessarily with native plants) for a variety of purposes, such as erosion control or amenity (Atkinson 1994).

REASONS FOR RESTORATION PLANTINGS

The reasons for tackling a restoration planting are many and various. This list is not inclusive:

Ecological

- To repair or restore degraded ecosystems or those under-represented in our protected area system.
- To conserve the genetic variation of common native plants and animals (Atkinson 1994).
- To improve ecological functioning at the landscape scale, such as linking protected areas and providing corridors for the dispersal of plants and animals.

Re-establishing the estuarine gradient from salt marsh to coastal bush at Ferrymead, Christchurch.

- To provide habitat for native animals.
- To reintroduce rarities from close by, or a little further afield where habitat is limited.
- To buffer streams, water bodies and remnant habitats from incompatible adjacent uses.
- To conserve soil and water values, e.g., erosion control.

Deer farming and nature conservation on Bob Swann's property in South Canterbury – a fenced-off remnant with enrichment planting.

Restoring coastal bush on back dunes at New Brighton.

Legal

- To protect and restore New Zealand's unique biodiversity under the Biodiversity Convention.
- To avoid, remedy or mitigate adverse effects on the environment under the Resource Management Act [sec. 5. (2)(c) and 17]. Because effects include past impacts [sec. 3], "remedy" can be interpreted as including the restoration of previously destroyed or degraded ecosystems.
- To require restoration as part of Resource Consent conditions, such as for mining activities. Sometimes restoration is promoted in applications for developments.

Using silver tussocks/wi for landscaping in an area of tall exotic grasses creates a maintenance headache. Prairie grass is invading the tussock, and weeding will become increasingly difficult.

Social and cultural

- To create aesthetic and amenity facilities, e.g., gardens, parks and recreational areas.
- To provide a collection of local species of interest, e.g., arboretums.
- To establish shelterbelts or native woodlots as a source of native timber.
- To provide a source of craft or medicinal plants.
- To reinforce a local sense of identity.
- To provide for educational and scientific study.

RESOURCES AND CONTACTS

For general information and advice, the Department of Conservation and local authorities are your main contacts. For DOC, biodiversity staff will be your key contacts. Many of the agencies listed in **Table 4** produce useful booklets, pamphlets and fact sheets, e.g., about weeds and animal pests.

Specialist nurseries supplying native plants should also be able to provide information about the supply and use of mulches, herbicides and other materials for restoration projects. When you obtain native plants from nurseries, you need to confirm they are locally sourced to avoid genetic pollution (see **section 7, Genetic source and provenance**). DOC offices or local authorities can advise you about suitable nurseries. The DOC Motukarara Nursery's plant catalogue provides useful information (see **Further reading**). Its gardens include ecological plantings of Canterbury communities, which show what plants can be used and what they look like.

Web sites can be frustrating as it is not always easy to find what you are looking for. For contacts about protection and restoration, a review of 12 council web sites suggests the following categories may be useful – environmental management or policy, planning, land management, environmental education, and parks and reserves. Pamphlets and other documents should be listed under 'publications'.

If you need specialist ecological advice, contact ecologists, ecological/environmental consultants or landscape ecologists. The yellow pages should list many of them, though ecologists are also employed by agencies like Landcare Research or Forest Research Institute. Most are likely to be costly, and not all will have the relevant experience. You should clarify their experience before employing them – local DOC or council staff may be able to help.

Table 4. Agencies providing free advice on restoration planting

Agencies	Agencies providing specialist advice
Department of Conservation - Conservancy and local Area Offices Web site: http://www.doc.govt.nz	Canterbury - DOC Motukarara Nursery RD 2, Christchurch
Regional Councils	District/City Councils
Fish and Game Councils Regional Offices	Native Forests Restoration Trust P.O. Box 80-007, Green Bay Auckland 7 Phone: (09) 636 7564
New Zealand Ecological Restoration Network PO Box 9000, Christchurch Web site: http://www.bush.org.nz (local contacts through web site).	

All restoration projects begin with a vision. You need to formalise your vision as goals and objectives to provide focus and direction for everybody involved in the project. Planning prescribes the steps and actions needed to ensure that your restoration proposal is well thought out and feasible. It ensures a consistent and logical approach to management (see **section 3, Management plans** – the same principles apply).

You may have several goals, some of which may have greater emphasis (Atkinson 1994). An example may be "*To restore a riparian corridor along (specified) stream".* To achieve this goal, your objectives should outline what management results are sought for specific issues or threats. They may, for example, state which communities will be restored or that stock will be excluded.

Consultation and costs

You need the support and co-operation of neighbours and local iwi. Your project could have impacts on adjacent landowners and properties, and you need to consider long-term issues like drainage and shading. Local iwi may have an interest in the project, and you should discuss it with them early on. Discussions with your local council will clarify if you need resource consents for any activities.

If your project is substantial, you will also need public support to attract funding. Cost estimates provide a reality check on what you can achieve and the funds required. Restoration costs vary enormously. Community-based projects may cost at least $10,000 per hectare, and fully commercial ones (from planning to final establishment) may be up to $100,000. In contrast, some projects using natural regeneration have cost a fraction of this. The organisations listed in **Table 2** (**section 2, Funding sources and contacts**) are your main sources of funding, but you may also obtain funding from community boards or through sponsorship. Once your project proceeds past the feasibility assessment stage (see below), you will need more detailed consultation and costings as part of a formalised restoration plan.

Feasibility assessment

A good feasibility assessment should reduce your chances of failure, cost overruns and disappointment. A commitment to maintenance by a group of dedicated people is essential to the long-term continuity and success of your project. The feasibility assessment should provide:

- An outline of the site, the proposed restoration project, its goals and objectives and a justification (Atkinson 1994).
- Confirmation of the long-term tenure and use of the site.
- An outline of major threats to the site, including a preliminary weed risk assessment.
- An indication of long-term community support, funding sources and the effects of the proposal on adjacent lands.

If your proposal is feasible, you should then prepare a restoration plan (**section 6, Key steps to effective restoration**).

6. Key steps to effective restoration

Your restoration plan should cover at least 5 years (Atkinson 1994). This is broadly equivalent to a management plan (**section 3**), and outlines the steps involved in the project. These steps are covered in the following sections.

SITE PLAN AND INVENTORY

A site plan includes an inventory of what plants and animals are present. It will clarify where different species should be planted, e.g., sensitive species that need careful siting to provide future seed sources. It may also identify places where physical alterations are appropriate, e.g., increasing water supply to a wetland. The biological information will provide a baseline for future monitoring and assessment of success. Ensure your site plan includes the following:

- Legal boundaries of the site.
- Approximate boundaries and areas of soil-landform units (slopes, terraces, basins, wet/moist/dry areas).
- Environmental gradients, e.g., rainfall and altitude.
- Favourable microhabitats, e.g., locally moist or sheltered areas.
- Human uses and any threats to the site.
- Needs or opportunities to alter the site, such as re-grading steep-sided drains.
- Current native and introduced vegetation – mapped if possible on an aerial photo.
- Exact locations of valuable or rare plants and serious weeds.

SITE HISTORY AND SPECIES LIST

Depending on the degree of damage to the site, you may find little to indicate what the former native plant communities were, particularly in lowlands. You may be able to determine the former communities by looking at the nearest similar sites, reviewing historic records of plants and animals or studying pollen records. However, information about ferns, mosses, lichens and invertebrates is likely to be poor.

Develop a species list for your plantings from the site plan and history, supplemented by good national and regional floras. There are several guides to restoration planting in New Zealand, but only a few are regionally based and take account of local species

and provenance. These include guides for Waitakere City, Christchurch, and Lyttelton Harbour. Some native plant nurseries have catalogues with species and habitat information.

A web-based tool (see http://www.bush.org.nz, under 'ecology') called "Planter Guide" lets you generate a species list for land or microsites anywhere in New Zealand below the natural treeline. You simply enter the appropriate ecological region for your land, the soil/drainage type and any other environmental attributes or uses. If you do not know the broad soil group, a built-in identification module will help you. The guide produces a list of potential species for the site and the appropriate sequence of planting. It does not necessarily indicate what grew on the site in the past. "Planter Guide" will continue to be refined, but it cannot be accessed when it is being updated.

In practice, only a quarter of the lowland flora is suitable for restoration planting – species that are vigorous and relatively tall-growing (trees, shrubs, tussocks, reeds and tall ferns). Propagation and cost limitations will also prevent you using all identified species.

Be careful with national species lists based on environmental tolerances as they often do not take account of regional variations. Your species list should reflect the main environmental gradients identified in the site plan. Local ecological advice is important when you are finalising the species list, particularly for drought and frost hardiness of the selected plants.

Common species should form the framework of the restored area, as they will be well adapted to the conditions. Colonising species provide fast growth, inhibit weeds and provide shelter for sensitive species. If species are matched to their micro-habitats, your chances of success will be greater.

PLANTING PLANS

Use your site plan, site history and species list to produce a planting plan in line with the goals of your restoration plan. You can draw each plant or group of plants on a map, or on idealised cross sections, which need to be interpreted before laying the plants out for planting. The number and type of plants needed are based on the area of each site and the soil-landform type. Get an ecologist to check your planting plan.

Groups of plants provide better protection and mimic natural patterns. On sand dunes, clumped planting reduces the risk of failure, helps to trap moving sand and reduces wind funnelling (Bergin 2000, Bergin and Herbert 1998).

Your planting plan should have the following elements:

- Species most common to the area should form the framework.
- Colonising species should be densely planted in open or exposed areas.
- Sensitive species should be planted in sheltered areas and microhabitats.
- Species providing bird food (nectar and fruit) should be planted.

- Local fire-tolerant or retardant species, such as broadleaf/kāpuka, ngaio, māhoe, NZ flax/harakeke and tussock grasses, could be included.

BUDGETING

Budgetting is important to ensure that all aspects of your project are properly funded. Plant costs are the main expense for volunteer-based projects, with addtional costs for fencing materials, mulch, and control of pests and weeds. Labour costs can be significant if you use professional advice or paid workers. Work out detailed costs at this stage.

- Allow for an on-going commitment to the project of at least 5 years, or longer for difficult sites.
- Break costs down into time periods that reflect different stages of activity and expenditure.
- Keep some funds for maintenance of the restoration site and its plants.
- Allow additional funds for any specialist advice.
- Update the budget whenever you initiate any further management actions.

RECORD KEEPING

Keeping good records in a safe place is important for future use and reference. Remember that restoration plans do not record all relevant information. You cannot rely on people's memories, and key people may leave over the lifetime of your project. An electronic spreadsheet can be used, as it is updated easily. You should keep back-up copies in safe locations. Alternatively, hand-written cards can be used and kept in a box - the must also be updated, and you should store duplicates separately.

- Record plant species lists, numbers of plants planted, their sources and costs.
- List contacts for volunteers and suppliers of material.
- Store monitoring assessments (methods used, results, management actions decided).
- Store any hand-written material, plans and photographs in a safe place.

7. Plant supply and propagation

GENETIC SOURCE AND PROVENANCE

Plants must be genetically sourced. It is essential that you source plants from similar communities as close as possible to the restoration site. Introducing a native plant to an area where it does not grow naturally may reduce natural diversity by cross-pollination with local species (genetic pollution). It can also confuse knowledge of natural species distribution and ecology (Nicholls 1990). Some texts do not address the issue of provenance and recommend using native plants from anywhere, providing they will survive and look attractive. This advice should **not** be followed in restoration projects. Similarly, you should not use artificially produced hybrids and variegated native plants as they do not reflect natural distributions and provenances.

Genetic pollution will also occur if you introduce native plant stock from distant populations of the species. Such stock can reduce the expression of local and regional character. Native plants are best adapted to growing in their local conditions, as the same species from different areas can differ in frost hardiness, drought tolerance, salt tolerance and pest resistance. Genetic pollution may also disrupt co-evolution between native plants and animals.

Severely depleted communities have lost much of their original diversity. If a local plant source is not available, you should at least obtain plants from the same ecological district. In highly modified areas or those with uncommon species, you may have to source plants from the fringes of the ecological district, from the wider ecological region, or even further afield. In this situation, always seek botanical advice first. As an example, *Euphorbia glauca*/waiūatua has been reintroduced to Canterbury from N. Otago, the nearest natural population.

- Deal only with nurseries that can guarantee genetic sourcing.
- Apply the principles of genetic sourcing if you are raising plants privately.

Caution

Always check the source of your plants. Some nurseries sell plants as local native species when they are not. For example, North Island lacebark/hoheria and kōwhai and exotic male fern are often sold at Christchurch fairs and garage sales as local natives.

PROPAGATION AND PLANT STOCK

Order your plants well in advance of when they are needed. From the time of seed collection, it may take 1-2 years until the plants are ready for planting, depending on the species involved.

If you are propagating plants yourself, growing from locally harvested seed is preferable to taking cuttings as seed produces greater genetic diversity. For detailed propagation information, refer to Metcalf 1995, Porteous 1993 and the Native Plants Course at the Open Polytechnic (phone 0800-507-333).

Genetically sourced nursery-grown stock is a better option than digging up wilding plants. Table 5 summarises the plant grades available at nurseries and their characteristics. Nursery-grown plants are likely to be of better quality and a more suitable size for planting than wildings, which have a lower survival rate. Ill-considered collecting may confuse genetic sourcing and deplete the source area. Wilding plants are also more likely than nursery-grown stock to introduce insect pests and diseases, which could infest existing remnants.

If you must use wilding seedlings and plants, do **not** take them from protected areas. The best sources are from second-growth forest or under pine trees that are to be logged.

Fungi associated with plant roots

Specialised fungi (mycorrhiza) are associated with the root systems of many plants. They assist with the uptake of water and nutrients, and may confer drought-tolerance to the host plant. The poor transplant ability of kānuka, mānuka and beeches may reflect a lack of suitable fungi. This problem may be reduced if you add ground up material from soil or the forest litter of natural stands to their containers.

When you are ordering plants from a nursery:

- For droughty, exposed or low-fertility sites, use root trainer stock (ideally 30 cm tall) so long as weed control will be effective. Larger or bare-rooted stock, such as NZ flax/harakeke, may need to be cut back.
- If weeds or pests are a concern on better sites, use container-grown plants 50-100 cm tall. Podocarps should always be planted at this size.
- Clip leggy nursery stock (e.g., kānuka and mānuka), but retain around 30 cm of foliage. This induces a more stocky form and reduces transpiration until the root system has developed.
- For sand dunes, select plants 30-70 cm tall, depending on the species (Bergin 1999, Bergin 2000, Bergin and Herbert 1998) and rainfall.

Table 5. Nursery plant grades and their characteristics

Plant grade	Description	Advantages	Disadvantages	Average Cost
O/G (Open Ground)	Grown in prepared beds. Bare-rooted plants lifted before delivery. Available generally for NZ flaxes, grasses, hebes, podocarps and pittosporums	Larger and well-established plants. Low cost.	Need extra care. Care needed with transport and storage. Soil may compact around roots. Optimal soil moisture and weed control needed.	$0.90 - $2.00
RT (Root Trainers): RTH (Hilson)-172 ml RTT (Tinus)- 352 ml	Plastic containers in sets of four hinged along the bottom. Vertical grooves to discourage spiral roots. Containers can be reused	Fast growth from seed tray to planting. Good root structure, little trimming. Low cost per plant. Roots can be inspected without disturbance. Easy to transport.	Need extra care Root damage possible when plant taken out of container. Small to medium plants need good weed control to overcome competition. Plants can be "leggy" with little lower foliage. Plants can't be placed individually on site.	$0.95 - $2.50
PB (Planter Bags): PB 2 PB 3 PB 5	Black plastic bags. Higher number = more soil, more roots and a bigger plant. Produces cylindrical root ball.	Bushier plants. Good height and root system. Easy to plant. May survive better in difficult sites.	Roots tend to spiral and become tangled. Overgrown roots need trimming. Bulkier to transport to the planting site. Higher cost per plant.	$3.00 - $7.50 depending on size and species
Pots RX 90 (90mm) O/P - Olive Pots (90 mm) 1 lt. (100mm)	Rigid plastic pots. Good shaped root plug. Medium size plant with balanced foliage growth. Pots can be reused.	Fast growth from seed tray to planting. Medium size plants. Good balance between roots and vegetative growth. Easy to plant especially in difficult sites. Low to medium cost per plant. Roots can be inspected without disturbance. Can place plants individually on site.	Overgrown matted roots need trimming. Medium size plants need good weed control to overcome competition.	$1.50 - $2.50

Note: The availability of open-ground or container stock varies according to species growth rates and the preference of the grower for producing different grades. Always choose stock that looks healthy, has foliage that is not soft and lush, and is not root bound.

8. Site preparation

Before you can start planting, some important tasks should be tackled. Good site preparation will make planting easier and increase the success of your project. If your site is well prepared, weed competition for light, soil moisture and nutrients should be minimal, and digging the planting holes should be easier.

FENCING

Fencing is usually essential to prevent grazing damage to plantings, but gates can allow unwanted access and rabbits can sometimes get underneath. You can seek fencing advice from DOC, local authorities, groups involved in other restoration projects and fencing contractors.

For managed grazing, you will need fencing to control the level and frequency of grazing. If rabbits are a problem, rabbit netting can provide effective long-term control, but it is expensive and needs regular checking. The base must be well buried and secured with rocks or logs, or extended out as a 30-cm apron, secured by wire pins.

- Fence the site to exclude grazing animals.
- Install rabbit netting where rabbits are a major problem.
- Locate fences to provide buffering around the restoration area where possible.
- Keep fences as straight and short as possible – cheaper and more effective.
- Use stiles for access across fences, not gates.

WEED AND PEST CONTROL

You will find information on the control of weeds, animal pests and domestic stock in **section 3, KEY STEPS TO EFFECTIVE MANAGEMENT** and in **section 10, MAINTAINING A RESTORATION PROJECT**.

GROUND PREPARATION

Friable soil makes planting easier and encourages root development. Normally, all you need to do is cultivate each planting patch with a trenching spade or crowbar. Mechanical ripping may be needed in mined areas, dry stony areas, artificially compacted sites, and sometimes clay soils. Do the work with a bulldozer or tractor with a winged ripper, when the soil is neither too wet nor dry. Clay soils are normally

Ripping dry, compacted ground, then strip spraying has improved the site for planting native shrubs and tussocks at McLeans Island, on the outskirts of Christchurch.

best ripped in late spring/early summer, while stony soils can normally be ripped at any time (R Simcock, pers.comm). If you are unsure about ripping, seek specialist advice.

For artificial or degraded soils, lime and fertiliser may be required. Only import topsoil or organic material if the existing substrate is very stony or rocky, or is composed of unconsolidated waste. With the latter, you may need to add up to 1.5 m of topsoil (Ross, Simcock and Gregg 1998). Be cautious when importing topsoil because you risk introducing foreign seeds and microbes.

- Loosen soil to a depth of around 0.5 m if possible (Meurk, Lucas Associates and Christchurch City Council (undated)).
- Add topsoil, organic material or fertiliser only if the original topsoil has been lost or degraded.

Cultivation and broadcast sowing of mānuka seed in Northland has resulted in a dense 1-2 m tall mānuka canopy after about 3 years.

VEGETATION CLEARANCE

You should remove all existing vegetation from the planting patches by spot-spraying or screefing (skimming off surface vegetation with a spade or grubber), to reduce competition for water and light. Grasses especially can overwhelm plantings. Avoid over-clearance as weeds will re-invade any disturbed ground (Porteous 1993). If you cannot plant the cleared patches promptly, they can be mulched and spot sprayed at planting. Alternatively, they can be left to allow other weed seeds to germinate before final spraying and planting (Porteous 1993). Mulching the cleared ground will reduce weed invasion and conserve soil moisture.

- Clear a 1-m patch for each plant (Meurk, Lucas Associates and Christchurch City Council (undated)).
- Do not over-clear surrounding vegetation.
- Do not damage other plant roots, or remove too much topsoil.
- Mulch exposed ground with the removed vegetation.
- Plant promptly (within a week, preferably sooner).

HERBICIDES

Always minimise the use of herbicides – some people have valid concerns about the use of toxic substances. Careless spraying can easily kill native plants (Fig. 2 shows the correct spray pattern to use).

Figure 2. Spray patterns

Circle pattern - poor result Side to side - better control

Using other methods as much as possible can reduce or confine herbicide use. For example, cutting and stump poisoning allows precise weed removal with minimal damage to other plants. Once vegetation has been cleared for planting, you should use mulching as your main method of weed control (see **section 9, Mulching** for details).

If you must use herbicides:

- Follow manufacturer's recommendations carefully.
- Follow recommended safety precautions to avoid harming people or contaminating waterways.
- Spray only in calm conditions.
- Use a wetting agent to improve adherence and results.
- Protect non-target plants by shielding them with cardboard, plastic board or plastic bags with the bottom cut out (Porteous 1993).

Table 6 summarises the main herbicides available for use at pre-planting and release times. **Table 7** lists major agricultural suppliers of herbicides, repellents, and fertiliser. For more information on the range of chemicals available, safety procedures and spray equipment, consult the NZ Agrichemical Manual, available from horticultural suppliers and some booksellers.

Table 6. Common herbicides used to control weeds

Herbicide	Mode of action	Weeds controlled and use	Toxicity	Warnings
Buster	Systemic contact herbicide (via the leaf). No residual life in the soil.	Grasses, broadleaved weeds and clovers. Provides short-term weed control	Poison.	Avoid contact with desirable plants and immature bark.
Gallant NF	Emulsifiable concentrate. Half-life in the soil of less than 24 hours	Selectively controls grasses. Can be mixed with Versatil, Gardoprim or Simazine for controlling clovers and broadleaved weeds.	Harmful substance.	Immediately after use, flush sprayer several times with clean water.
Glyphosate Roundup, Renew	Absorbed through foliage and translocated to all parts of the plant, including roots. Half-life <14 days in aerobic soil, and 14-22 days in anaerobic conditions.	Controls most annual and perennial grasses and broadleaved weeds. Used as a pre-planting or a release spray. Can be used successfully as a stump poison.	Low toxicity.	Spray drift must not contact foliage or green-bark of desirable trees.
Interceptor (Organic spray - new product with limited information on weed control in establishing native plants)	Emulsifiable, non-selective, contact foliage spray. Penetrates green plant tissue, and disrupts cellular physiology. Fast acting (within minutes) but may require additional treatment.	Controls annual weeds and grasses, and perennial weeds. Can be used as a pre-planting or release spray.	Low toxicity.	Spray drift may damage foliage, fruit or unprotected green bark of desirable plants. Also kills algae, mosses and liverworts.
Simazine	Absorbed only through roots of germinating plants. Soil residual life ranges from 3 - 12 months. Half-life varies from 27-102 days. Low leaching potential.	Prevents the emergence of a wide range of annual and perennial grasses and broadleaved weeds.	Flowable Simazine - poison. Others - low toxcicity.	Spray drift may cause serious damage to other plants.
Terbuthylazine (Gardoprim)	Absorbed through roots and leaves. Pre- and post-emergent half-life in biologically active soils is 30 - 60 days.	Controls a wide range of annual and perennial grasses and broadleaf weeds. Apply pre-planting or as a release.	Hazardous substance	Follow manufacturers recommendations. Avoid using near desirable plants, where the chemical may be leached into their root region.
Versatil	Absorbed by leaves, stems and roots.	Controls thistles, yarrow, clovers and many difficult flat weeds. Can be mixed with other herbicides for the control of additional weeds. Do not apply to legumes or compositae (daisy family)	Harmful substance.	Follow manufacturer's recommendations. Remains active on plant material - do not use clippings from treated areas for compost or mulch, within 6 months of treatment.

Herbicides can be dangerous!

Before you purchase herbicide, carefully read the label or the Material safety data sheet - MSDS (available from suppliers) to answer the following questions:

- Is it the right product for the job?
- Are there restrictions on its use?
- Can the product be used safely under your conditions?
- What environmental precautions are needed?
- Do you have the right equipment to apply it?

Before you apply herbicide, read the label to answer the following questions:

- What protective clothing is needed?
- How much to use?
- How and when to apply it?
- What can or cannot it be mixed with?
- What is the withholding period?
- What warnings, precautions and first aid measures need noting?

Table 7. Agricultural suppliers

Agri chemicals/fencing/pest control baits and bait station suppliers/tools/sprayers: Pyne Gould Guinness (03) 343 3999 Greenfield (03) 365 0677	**Wholesalers of pest control: traps, baits and bait stations:** Trappers Cyanide (03) 359 4150 Pest Management Services (0800) 111 446 Feral Control (09) 433 3273
Animal repellents: Nufield Marketing (Plantskydd) (03) 348 0799 Roe Koh and Associates (Plant Plus) (03) 343 0345 Kiwi Care (Thiro-protect) (03) 398 0778 Aorangi Forestry Services (Treepel) (03) 689 7993 Southern Woods Nursery (Liquid shotgun) (03) 347 9221 Elliot Chemicals (X-Pel) (09) 521 1562	**Windbreak/weedmat (bulk suppliers):** Donaghys Industries Ltd. (0800) 942 006 Cosio Plastics (025) 335 704 (weed stop/wire, pins/plastic pins). Permethane (09) 828 5179
Bulk suppliers of windbreak cloth/weedmat/fertilisers/weed killers/irrigation materials: Carann (wholesale) (03) 359 7914 Egmont Seed Company (wholesale) (03) 349 5546 Fuitfed (03) 349 9948 Hortlink (03) 348 8220 Yates N.Z. (wholesale) (03) 349 9223	**Woolmulch Biomac (erosion and weed control matting):** Maccafferi NZ Ltd (distributors) (03) 349 5600
Fencing and fencing contractors - Refer to Yellow Pages.	**Home garden suppliers of windbreak cloth/weedmat/fertilisers/weed killers/irrigation tools:** Mitre 10 Smiths City Placemakers Other hardware stores
Irrigation See 'Irrigation Equipment and Services' in the Yellow Pages.	**Organic mulches** See 'Garden Supplies' in the Yellow Pages.

Disclaimer - this table lists suppliers, which at the time of publishing this guidebook were known sources of these products or services. They are not necessarily endorsed or recommended by the Department of Conservation. If you wish to update this list please contact the Department of Conservation Nursery at Motukarara (03) 329-7846.

PROVIDING TEMPORARY SHELTER

Providing shelter for planted natives is particularly important in difficult or exposed sites. Your options range from retaining shrub weeds as nurse plants, to planting shelter, to using shade or wind cloth for small areas.

Retaining shrub weeds

Consider retaining woody weeds as nurse plants to provide shelter for planted natives, e.g., crack willow along riparian areas, gorse, broom, elderberry, tree lupin and tree lucerne. Unnecessary removal of trees and shrubs is expensive, it may create new weed problems and eliminate valuable shelter, and tree removal may upset local people. For detailed information on using existing gorse and broom as nurse plants, see **section 4, Managing succession through shrub weeds**.

Thinning, line-cutting and planting

A hybrid approach that accelerates natural succession could be helpful (use **Table 3. Factors affecting succession through gorse and broom** as a guide to when this is appropriate). This requires thinning or line cutting, depending on the age and openness of the shrub weeds. Native plants established in the cleared spaces will eventually form a canopy over the shrub weeds and suppress them.

Broadleaved trees planted along cleared edges of gorse reduce gorse regeneration and provide a seed source that will accelerate the succession of native species under the maturing gorse.

Planting the boundaries densely, with only scattered planting (5-10 m spacings) in the interior, is an option. The boundaries will need intensive management until native trees are established (say 2-3 m tall), after which native dominance will be achieved with minimal maintenance. Similarly, planting into patchy gorse and leaving it for 3-5 years will result in some gap-filling by shrub weeds, but they will eventually be suppressed.

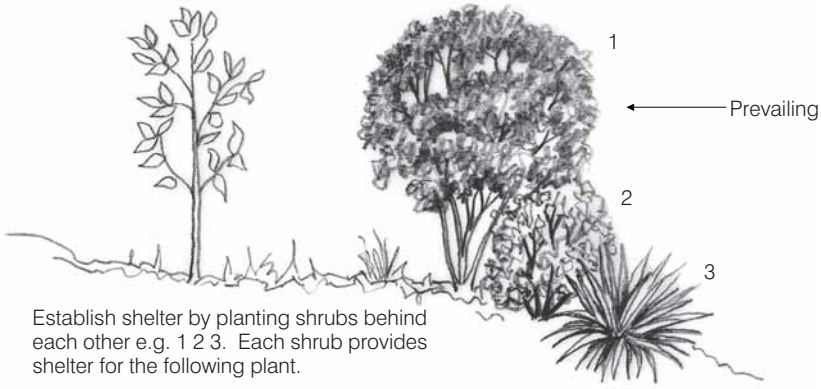
Do not over-thin or clear. This may create more problems than it solves by letting in light and allowing suppressed weed seedbanks to spring into life. The Christchurch City Council has trialled the shredding of several hill blocks of shrub weeds with a mechanical chipper, in preparation for planting through the slash to hasten natural succession. Their approach was in response to pressure from residents over the weeds and fire risk, and finance was available at the time. Invading grasses were sprayed and the planted natives were mulched with paper discs. After two years, the slash had largely disappeared and shrub weeds had re-established from the seedbank. While this approach has allowed easy access for planting and maintenance, increased weed control will be needed until a native canopy establishes.

Where you have broom or gorse at or near the treeline, an untested option would be to inter-plant local native species, e.g., mānuka, dracophyllums, olearias, hebes and cassinia/tauhinu (see **section 4, Managing succession through shrub weeds**). Their growth will be slow, like that of the shrub weeds at this altitude.

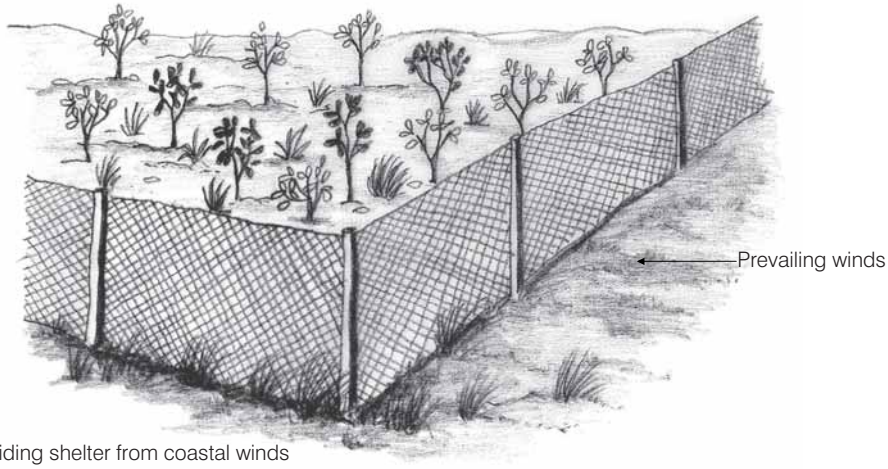
Planted and artificial shelter

On some sites you may need to plant nurse species to provide shelter. Always attempt to establish a native canopy for sheltering other native plants. Sometimes you could consider planting temporary fast-growing exotic species (e.g., tree lucerne in dry sites), but this should be a last option. Tree lucerne can spread beyond the site if adjacent land is not grazed.

If the site is exposed, windbreak or shade cloth can provide shelter and quick results, but this is practical only for small areas. Planting borders of dense, shrubby species adapted to the conditions should limit the need for this approach.



Establish shelter by planting shrubs behind each other e.g. 1 2 3. Each shrub provides shelter for the following plant.



Providing shelter from coastal winds

9. Planting

TOOLS AND PEOPLE MANAGEMENT

You have two broad labour options for planting projects. You can rely on voluntary labour, or you can make use of trained people or experienced contractors, either to do the work or to advise and supervise other workers.

Voluntary labour greatly reduces costs and encourages community involvement. There is merit in volunteers being involved in on-going management of the restoration site, as it provides continuity. Bear in mind that volunteers have a wide range of skills, energy and commitment. On the down side, some volunteers may lack experience and will make mistakes, and supervision can require a lot of commitment and time. If your project is well established, you may find that casual voluntary labour is counter-productive and that it is better to build up a register of tried and proven individuals. Specific workdays can be organised for these helpers.

Careful management is needed to ensure people enjoy themselves and the planting is productive and done correctly. Make sure you tell volunteers the starting time, how to find the site and what to bring – tools, sun protection, warm clothing, lunch and drinking water. The project organisers should provide some of these, as it is important to maintain the good will of volunteers. Health and Safety requirements will probably mean that water, extra supplies of sunscreen and first aid materials must be provided.

Your volunteers will need careful supervision and guidance. One person should co-ordinate the entire operation, and they should be visible (bright safety vest) and centrally located to direct people to the correct places, or to other supervisors.

Even experienced gardeners may be unfamiliar with the conditions of semi-wild places – stony, shallow, compacted or dry soils where the key priority is to prevent the plants drying out. You will need to demonstrate the correct planting technique, and provide a handout with clear instructions or diagrams. Experience shows that techniques must be reinforced several times, as people's expectations are influenced by their home gardens with soft soils and water on tap.

- Ensure that sufficient tools are available for the different stages of the project.
- Obtain any specialist tools and equipment well in advance of being needed, e.g., planting spades, tractors, chainsaws and spray equipment.
- Follow Health and Safety and any other legal requirements, like those relating to the use of poisons and machinery.
- Closely supervise inexperienced people, particularly children, families and school groups.
- Encourage children in particular to wear hats and use sunscreen if sunburn is likely.

- Make sure supervisors oversee the planting work.
- Limit the number of plants per person or group, so the planting is done properly and not rushed.
- Do not over-work volunteers, as they may not come back and are more likely to make mistakes.

TIMING

The time of planting depends on how prone the site is to drought and frost, and the species being planted.

- Plant in autumn and winter where frosts are light, winters are mild and summers are likely to be dry. This will allow maximum root development while moisture is available.
- Plant less hardy species or on very cold sites in spring when the frost risk is less. Alternatively, plant under shelter or after earlier plantings have established sufficient cover.
- Plant wetlands and moist stream banks in late spring to early summer, after the water table has fallen.
- Plant sand tussock, pīngao and spinifex/kōwhangatara in foredunes from autumn to spring (Bergin 1999, Bergin 2000, Bergin and Herbert 1998).

Caution

Do not plant nursery-grown woody wetland plants in saturated soils – they can die as aerated root tissue, which allows them to breathe, will not have developed.

Avoid planting on hot, sunny or windy days (Porteous 1993) if possible. If this is not practical once arrangements have been made with volunteers, you must keep plant roots moist and cool.

Transporting and storing plants

It is important to store and transport plants as suggested, or they will dry out or be damaged.

- Do not leave containers or plants removed from root trainers in direct sunlight.
- Store plants out of the sun - use shade cloth if necessary.
- If plants are stored for an extened period, avoid excessively shady areas a they will become leggy and soft.
- Water stored plants regularly and thoroughly, every 2 days in hot weather, otherwise every 3-4 days.
- Shelter plants from the wind and keep moist during transport in an open trailer or vehicle.

PLANT NUMBERS AND SPACINGS

Distribute plants centrally, or put them out in their planting places before people arrive. The latter will ensure there is no wastage, for example all the expensive podocarps being planted in one place, too close together.

Waterway enhancement on the Heathcote River, Christchurch. Dense sedge tussocks/pūkio at the water's edge prevent weed invasion and provide shelter, shade and a source of insects for in-stream wildlife.

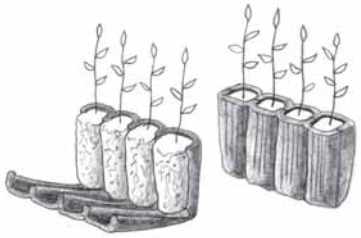
Normal planting density is around 1 plant per square metre. This is more costly than planting at wider spacings but it will achieve more rapid control over grass and weed competition. Planting small stock densely will minimise costs and allow for losses from natural mortality. If grass control will be infrequent, less dense planting of larger grade plants may be appropriate on moist sites or in deep soils. Remember that you will not be planting all species at the outset, and you need to allow for this in your placing of the plants.

In practice, you will use different spacing for different plant types.

- Allow spacings of 3-10 m for large canopy and podocarp trees (1000-100 plants per hectare).
- Allow 1-2 m for small trees (kōhūhu), and 1 m for shrubs and large tussocks (toetoe) (10 000-2500 plants per hectare).

- Allow 0.5 m for ground cover plants and small tussocks (ferns, rushes and sedges) (40 000 plants per hectare)
- Allow planting densities of 0.5-0.6 m on sand dunes for pīngao, sand tussock and spinifex/kōwhangatara (40 000 plants per hectare) (Bergin 1999, Bergin 2000, Bergin and Herbert 1998).

Figure 3: Restored forest showing different spacings of large and small plants.



PLANTING TECHNIQUES

If planting is not done properly, your valuable plants will inevitably die, wasting time, money and effort. You need to show people how to open root trainers, so they can be re-used and the plants are not damaged. The soil-root mass should be moist, but not wet or it will be hard to handle. Each plant must be planted at the correct depth to make best use of soil moisture or to avoid waterlogging in wet sites.

Planting depths

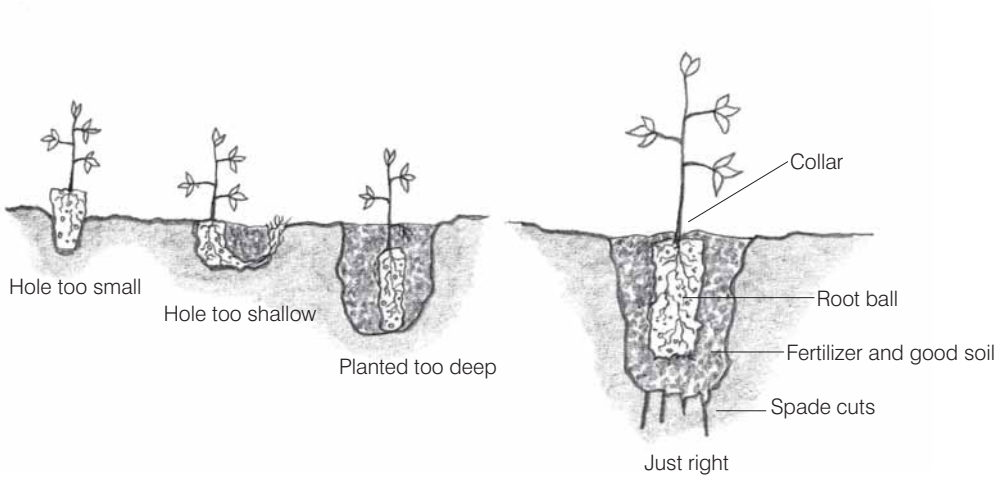
The planting hole needs to be deep enough for the collar (base of the stem) to sit:

- 1-2 cm below adjacent soil surface on sites with reasonable moisture.
- Up to 5 cm below the adjacent soil surface on dry sites.
- At least 5 cm below the adjacent sand surface on sand dunes (Bergin 1999, Bergin 2000, Bergin and Herbert 1998).
- 2 cm **above** the adjacent soil surface in saturated sites.

Planting steps


Planter bag

- Soak plants before planting, but leave to drain and keep out of direct sunlight.
- Skim any grass regrowth off the soil surface using a spade or grubber (screefing). Do not damage other plant roots or remove too much topsoil.
- Turn over the cleared patch (Porteous 1993), or use the removed grass as a mulch.
- Dig a hole twice the size of the plant container, score the sides and loosen soil in the bottom of the hole.
- Add water to the hole in dry areas, if it is available.
- Remove plant from the container carefully, retaining as much soil around the roots as possible.
- Untangle or prune roots if necessary.
- Trim the bottom 2-3 cm off the root plug of root-trainer plants to encourage root growth (Porteous 1993).
- Place plant in hole so the base of its stem is the correct depth below the adjacent soil surface.
- Gradually add soil around the roots, firming each layer.



- Firm the soil well after planting, leaving a slight depression (in unsaturated soils) to catch any rain or water run-off.
- In droughty situations, thoroughly water the plants and do not water again for at least 2 weeks.
- Apply animal repellents immediately before, or at planting time (see **section 10, Animal Pests and Stock**, and **Table 8**).

Good root structure is critical

Avoid root-bound plants. If they have to be used as a last resort, severely root prune them with a sharp spade, secateurs or knife. Root-bound plants are slow-growing and vulnerable to damage. This is more of a problem with woody than grassy plants.

- Producing root-bound plants is bad nursery practice and should be discouraged. If you have concerns, discuss them with your plant supplier.
- Fibrous roots can be trimmed, but if more substantial roots are severed, the plant will be vulnerable in a dry or stressed site.
- Plants stored for long periods need to be potted on to avoid them becoming root-bound.

Staking small and slow-growing plants helps prevent them being lost, smothered by grass, or damaged by weedeaters. Matiu/Somes Island coastal bush, wētā and tuatara restoration project.

After planting is completed, you could mark small, slow-growing or valuable plants with a stake to help locate them for later maintenance, especially if grass growth is likely to be vigorous. Do **not** tie plants to the stakes as it may damage them as they grow. In urban areas, stakes can attract vandalism. Use artificial shelter if needed, but be cautious about using tree protectors – they can restrict the development of branches and foliage or cause heat stress. Tree protectors are only suitable for tall leafless single-stemmed trees like ribbonwood/mānatu and lacebark/houhere. Rain/water crystals could be added to the planting soil in drier areas to help retain moisture, though their effectiveness in the outdoors is unclear – in two sand dune trials, Hydrogel had no effect on plant growth or survival (Bergin and Kimberley 1999).

Tree protection is especially useful for valuable and slow-growing podocarps.

FERTILISER AND WATERING

In general, you do not need to apply fertiliser at time of planting. Broadcast fertiliser can easily give a competitive advantage to weeds. Fertilising and over-watering can also cause excessive soft growth, and reduce a plant's hardiness.

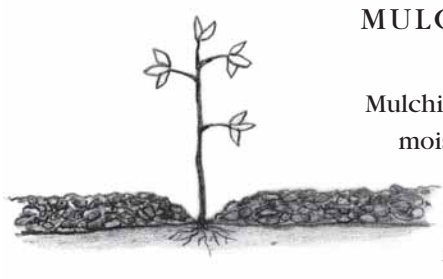
Fertiliser will not normally be needed on natural soils. Even on difficult sites with poor soils native plants will grow well without fertiliser, and planting the correct

species at the right time of year should suffice (Porteous 1993). You should use fertiliser only where there are nutrient deficiencies or toxicities (Ross, Simcock and Gregg 1998). Sites that are degraded (slips/scrapes) or poisoned (mine/landfill) will benefit from N, P, K, S and lime to boost growth and plant succession or overcome toxicity (Langer, Davis and Ross 1999).

The other main exception is on foredunes, where existing vegetation benefits from fast release N fertiliser (see **section 4, Coastal Dunelands and Banks** (Bergin 1999, Bergin 2000, Bergin and Herbert 1998)).

If fertiliser is used at planting, don't feed the weeds. Incorporate slow-release granules with soil in the planting hole, or sprinkle around the weed-free base of the target plant. Slow-release tablets like Agriform (Scotts) can be added to the planting hole. Alternatively, after planting make a 20-cm deep hole with a crowbar, and drop in a tablet beneath the foliage.

Watering should not be necessary after planting if well-conditioned nursery stock are planted in the right place at the right time of the year, then mulched. In dry sites, droughts are unpredictable and irrigation (if practical) in the first year may reduce the loss of valuable plants and time. Plants should be gradually weaned off this water. Watering at very dry, remote sites can be done using containers that drip water onto the soil around the plants.



MULCHING

Mulching the plants with a layer of permeable material is essential to retain soil moisture, reduce weed growth and provide soil insulation. It is important to mulch sufficiently deeply, but be careful not to bury small plants. Use organic material if possible, as it breaks down to supply nutrients to the soil. These mulches will need renewing over time to maintain effective weed control.

Mulch the entire cleared area around each plant. Do not mulch naturally wet areas and stream edges as saturation and anaerobic conditions can develop – mulch can also be washed away and cause stream blockages. Once your plants are established and the canopy closes, mulching should not be needed.

This wool mat on a steep river bank will suppress weeds, retain moisture and reduce erosion.

Organic mulches

- Newspaper (at least 6 sheets thick)
- Fine bark chips (10cm deep)
- Wool mat or carpet underlay
- Coconut matting
- Straw or dead vegetation (may contain weed seeds).

Other types of mulch can be useful for weed suppression, but each has disadvantages:

- **Stones** can be used where they are available (e.g., in riverbeds), but reflected heat could scorch large-leaved plants.
- **Paper discs** can be used, but must be held down with stones, turfs or pinned with wire. The 30-cm discs are too small as grasses can still shade the plants and the weed roots extend under the discs. Thin discs break down relatively quickly; larger thicker ones may be more effective.
- **Synthetic weed mats** can be pinned down with wire and used on steep sites. However, they do not decompose, they prevent the development of an organic layer on the soil and are difficult to remove when they are no longer needed.
- **Car tyres** (two or three) can be stacked around plants at dry exposed sites to provide shelter, deter animals and suppress weeds. It can be awkward to move large numbers of tyres around, and they need to be removed later as they are an eyesore.

10. Maintaining a restoration project

To maximise success, you will need to maintain the site and its plants for several years (typically 3-5 years). It is important to be committed to this, and not to undertake more planting than you can look after. Retain additional funds for maintenance, as unexpected problems will inevitably arise, e.g., plant losses from unseasonable weather, browsing or grazing. Inspect sites regularly to identify maintenance requirements.

Caution

It's better to plant a few plants and look after them properly, than to plant a lot and lose most of them.

WEED CONTROL

On-going weed control is essential to reduce competition, especially from grasses. For slower growing species, weeding may be needed for up to 3 years (Porteous 1993). Mulching is the main method of weed control until the native plants are well established (see **section 9, Mulching**). During this period replace mulch as needed. Other weed control methods may still be necessary, but you should minimise the use of herbicides as many people are concerned about the use of toxic chemicals (see **section 8, Herbicides**). Planting contractors sometimes use pre-emergent sprays like Simazine and Gardoprim to provide longer weed control.

- Apply regular weed control to minimise competition - this may be necessary every month in the growing season (Meurk, Lucas Associates and Christchurch City Council (undated)).
- Use grubbers, slashers, sickles and weedeaters with extreme care.
- Spot-spray carefully with biodegradable herbicide if needed.

Caution

Poorly managed weed control is a major cause of native plant death.

- Weedeaters can ring-bark planted trees.
- Grubbing can damage sensitive roots.
- Native plants are sensitive to herbicides, especially podocarps.
- Spray drift can easily destroy an expensive plant, wasting time, effort, and money.

Planted pingao and NZ blue euphorbia/ waiūatua beginning to form a natural dune gradient in former marram grass at New Brighton, Christchurch. However, African ice plant threatens to invade the establishing pingao.

ANIMAL PESTS AND STOCK

Animal pests can destroy your efforts if you do not take precautions. Refer to **section 3, Animal pest control** for control methods. Poison baits for controlling rabbits and possums are listed in **Table 8** below.

Where trapping, shooting or poisoning is inappropriate, animal repellents are a useful alternative for discouraging browsing by rabbits, hares, possums and goats. They are non-toxic, easy to apply and they normally reduce plant losses by over 50% (Montague 2000). There are at least six repellents on the New Zealand market (see **Table 7. Agricultural suppliers** for a list of products and suppliers). Cost ranges from 7.5 to

25 cents per 30-cm seedling. Repellents applied at or before planting time will give protection for about 3 months, depending on rainfall (Montague 2000). Some repellents may reduce plant growth. Some require mixing, though two come as ready-to-use liquids and all are sprayed onto plant foliage. You can make your own repellent by mixing 5 fresh eggs, 150 ml of acrylic white paint and 600 ml of water (Canterbury Regional Council (undated[1])).

Shields or protective sleeves can be used around stems/trunks – do **not** enclose the foliage, as small plants may suffer heat stress. This also reduces damage by native birds such as pukeko.

Dead gorse branches laid around young plants may offer temporary protection against browsing by rabbits and hares.

- Inspect and repair fences regularly.
- Re-apply animal repellents if necessary.
- Control animal pests.

Caution

If something can go wrong it will – avoid disappointment and plan for disaster. Pests will destroy your efforts if precautions are not taken.

Table 8. Animal pest control poisons

Poison	Product Brief	Precautions	Recommended Uses
Campaign Pellets (Distributed by Key Industries)	Cereal based bait, for killing possums. Acrive ingredients cholecalciferol, vitamin D3 (calcium). Cholecalciferol mobilises stores of calcium from the bones into the bloodstream: elevated blood calcium will cause death within a few days. A single feed of 10 - 15 g will be leathal to possums.	Low toxicity to bird-life and humans, but potentially hazardous to dogs (or cats used to dry foods). Insoluble in water and degrades in the presence of heat, light and oxygen. Follow manufacturer's handling recommendations.	Controls possums. Must be used in bait stations only, out of reach of children, stock and pets. Use 100 g - 200 g per station per 100m or per hectare. Inspect and replace until no more bait is taken.
FeraCol (Distributed by Feral Control)	Oil-based peanut flavouredpaste containing cholecalciferol, vitamin D3 in a concentrate form, toxic to possums (low tolerance to calcium). See above for poison effects.	Pets and farm dogs should be discouraged from eating poisoned carcasses. Low risk to the environment and non-target species as it is metabolised and is completely biodegradeable. Follow manufacturer's handling recommendations.	Use biodegradeable bait bags provided; nail to a wooden frame away from the reach of children and domestic animals. Position the bait in an obvious area of possum activity.
Pindone Possum Pellets and **Pindone Rabbit Pellets** (Distributed by Pest Management Services)	A poisonous cereal based bait, dyed green to discourage birds. Contains Pindone in the form of a bait. A slow-acting anti-coagulant that must be consumed for several days. The toxin reduces blood clotting resulting in internal haemorrhage. Death occurs 4-11 days after consumption.	Avoid contamination of any water supply with bait or empty container. Handle with extreme care; follow manufacturer's handling recommendations. Remove all stock from the area being treated and withhold for 4 weeks.	Use enough bait to feed for two days and repeat if necessary. Use bait stations for possums and broadcast according to instructions for rabbit control. Do not bait if heavy rain is expected within 1 day, unless protected from rain.

Poisons and bait stations are available from horticultural and farm supply outlets. Only licensed operators can apply other poison baits. For a list of operators, consult your regional council, district/city council or DOC.

PLANT REPLACEMENT/BLANKING

Plant losses will be inevitable. Reasons for losses include: poorly conditioned plants, using the wrong plants for the site, grazing/browsing, lack of maintenance, ring barking by weedeaters, spray drift and vandalism or theft. You may also lose plants to natural causes such as unseasonable drought/frosts, insect epidemics (caterpillars), and disease (root rot and cabbage tree sudden death). You can help improve restoration techniques by recording information about your project performance.

- Replace dead plants to maintain vegetation density.
- Clarify and document the reasons for plant death.

SECONDARY SPECIES

Your initial plantings will be fast-growing species that form the framework of the future ecosystem. This framework will provide suitable conditions for 'secondary species', those that need shelter and nurturing (e.g., frost-tender trees, ferns, vines and some animals), though this may take several years. Colonising plants provide shelter in which you can underplant secondary species. They also improve the soil and build up biomass, allowing ferns, mosses, lichens and animals to establish naturally, thus increasing biodiversity. Transferring animals from other sites can accelerate this process, but you may need agreement from others, such as DOC and iwi.

- Plant secondary species once shelter has been established by hardier colonisers, or existing vegetation.
- Remember to budget for secondary species.

REMOVING SHELTER

Gorse and broom will eventually be shaded out, so you do not need to remove them, except along boundaries with other properties. It takes 10-20 years for gorse to be suppressed naturally in moist environments.

If introduced trees, such as sycamore eventually threaten to suppress the planted natives or are likely to spread, you should remove them. Sometimes ringbarking large trees and leaving them to die and collapse in situ may avoid the need for felling, but keep public safety in mind. There is merit in using professional tree fellers to remove large trees so that damage to other plants and safety risks are minimised.

You need to be aware that the sudden removal of a nurse canopy may check the growth of desired plants by increasing exposure to sunlight, frost and weed growth.

- Remove exotic nurse plants only if necessary.
- Remove wind cloth shelters once colonisers are established

MONITORING AND ADAPTING MANAGEMENT

Restoration in New Zealand is a relatively recent endeavour and we still have much to learn. Inevitably you will find the unexpected and learn useful lessons. Careful observation, trial and error and more formal field trials will all contribute to increased knowledge. If you monitor your restoration project, you will help clarify the requirements of different species and the effectiveness of various management techniques. Specialist monitoring input may be needed to clarify complex issues, such as the role of animals and microbes in succession. In either case, your project can contribute to improved knowledge on restoration. See **Section 3, Monitoring** for an outline of monitoring methods.

Refer to "Eco Track", the NZERN webpage method of storing data on plant performance in restoration sites (see http://www.bush.org.nz). It is expected to be available in some form, by about June 2001.

- Establish regular monitoring.
- Keep good records.
- Refine restoration techniques using information obtained from monitoring or from other projects.

Further reading

A guide for planting and restoring the nature of Waitakere City. Lucas Associates and Stephen King 1997. *[Book - provides an overview and guidelines for restoration, based on underlying ecosystems, and information about invasive weeds]*

An illustrated guide to common weeds of New Zealand. Roy B, Popay I, Champion P, James T and Rahman A 1998. *[Book – photographs and descriptions of a wide variety of weeds. A number of native plants are listed as weeds, but little explanation is given for their selection. We do not think they should be described as weeds]*

Christchurch waterway maintenance plant guide. Weeds, and how to tell them from similar looking plants. McCombs K, Meurk C and Morland K 1999. *[Book, available on request from Christchurch City Council– contains clear photographs and descriptions for easy plant identification]*

Coast Care Bay of Plenty Programme, brochures 1-6. Environment Bay of Plenty (undated). *[Pamphlets – outline coast care concept, sand dune functioning, foredune vegetation, pīngao, spinifex, dune usage and protecting dunes]*

Coastal sand dunes, form and function. Hesp PA 2000. *[Booklet – describes the different types of dunes, their functioning and dynamics, erosions issues and the importance of coastal dunes]*

Gully restoration guide. A guide to assist in the ecological restoration of Hamilton's

gully systems. Wall K and Clarkson B 2001. *[Booklet – a step by step guidebook on gully restoration. Includes a gully profile, information on soils, native plants to use, and weed identification and control]*

Managing riparian zones: a contribution to protecting New Zealand's rivers and streams. Collier KJ, Cooper AB, Davies-Colley RJ, Rutherford JC, Smith CM and Williamson RB 1995. *[Two books – volume 1 outlines why riparian zones are important, and the natural processes affecting rivers and streams; volume 2 provides guidelines for specific problems like bank instability, grazing and increasing habitat diversity.* ***Note –*** *for ecological restoration, we recommend the use of cabbage trees, NZ flax, toetoe, kōhūhu (Pittosporum tenuifolium), karamū (Coprosma robusta) and lowland ribbonwood for erosion control, rather than exotic trees]*

Managing waterways on farms: a guide to sustainable water and riparian management in rural New Zealand (draft). Ministry for the Environment 2000. *[Book – outlines what a healthy waterway is, the impacts of agriculture and forestry, managing problems and restoring riparian vegetation; includes 16 case studies.* ***Note –*** *for ecological restoration, we recommend the use of cabbage trees, NZ flax, toetoe, kōhūhu (Pittosporum tenuifolium), karamū (Coprosma robusta) and lowland ribbonwood for erosion control, rather than exotic trees]*

Motukarara nursery plant catalogue 2001. Department of Conservation. *[Booklet – outlines site preparation, planting and maintenance, and lists plants according to their form, size and provenance. Plants are recommended for different sites and purposes]*

Native forest monitoring. A guide for forest owners and managers. Handford, P. 2000. *[Book – provides detailed information on methods, fieldwork, data analysis, indicators of forest health, and the level of skill and precision needed for the methods used]*

Native forest restoration. A practical guide for landowners. Porteous T 1993. *[Book – comprehensive coverage of managing remnants, with detailed restoration techniques]*

Natural areas of Christchurch: Evaluation and recommendations for management as heritage. Meurk CD, Ward JC and O'Connor KF 1993. *[Book – contains management guidelines for wetlands, grasslands, shrublands, woodlands, dune slacks, salt marshes and sand dunes]*

New Zealand's wetlands. A management guide. Buxton R 1991. *[Book – describes different types of wetlands and their functioning, and provides management and restoration guidelines and summaries]*

Otipua wetland Saltwater Creek, Timaru. A community project. Lucas Associates 1997. *[Book – an example of restoring an estuarine ecosystem from former farmland]*

Regeneration of native forest on Hinewai Reserve, Banks Peninsula. Wilson HD 1994.

[Paper in journal – describes natural succession under gorse and broom based on a minimum interference policy. Outlines monitoring, successional trends and the importance of removing browsing pressure]

Rehabilitation of coastal foredunes in New Zealand using native sand-binding species. Bergin DO and Kimberley MO 1999. *[Book, available from DOC Science Publications – covers pīngao, sand tussock and spinifex, which are separately addressed in other references by Bergin]*

Resource Management Act 1991. *[Part I,3; Part II, 5(2)(c)]*

Restoring Avoca Valley Stream - a community model. Lucas Associates and Christchurch City Council 1998. *[Book, which has been distributed widely to other councils - contains generic stream restoration guidelines, including planning of restoration, tangata whenua values, waterway enhancement and biodiversity values]*

Review of information on riparian buffer widths necessary to support sustainable vegetation and meet aquatic functions. National Institute of Water and Atmospheric Research 2000. *[Book – site visits were made and native vegetation was considered to be more sustainable over the long term than exotic vegetation]*

Riparian zones. A guide to the protection of Canterbury's rivers, streams and wetlands. Canterbury Regional Council (undated[3]). *[Pamphlet, available from Environment Canterbury – outlines erosion control, habitat values, pollution control and riparian planting.* ***Note –*** *for ecological restoration, we recommend the use of cabbage trees, NZ flax, toetoe, kōhūhu (Pittosporum tenuifolium), karamū (Coprosma robusta) and lowland ribbonwood for erosion control, rather than exotic trees]*

Streamside planting guide. What to plant and how to maintain native plants along freshwater streams in Christchurch. Meurk C, Lucas Associates and Christchurch City Council (undated). *[Pamphlet, available from Christchurch City Council – outlines the main planting steps, stream bank zones and provides a species list]*

The coastal lands of Waimakariri-Rakahuri (Ashley). A preliminary report developing a community vision. Lucas Associates 1998. *[Book - provides an overview and guidelines for restoration, based on underlying ecosystems]*

The natural succession option. A strategy to replace gorse and broom on Canterbury's marginal pastoral lands with native forest. Canterbury Regional Council (undated[2]). *[Pamphlet, available from Environment Canterbury – outlines natural succession by native woody species, and factors affecting succession potential. It is based on the booklet by McCracken 1993, which is straightforward and provides more detail]*

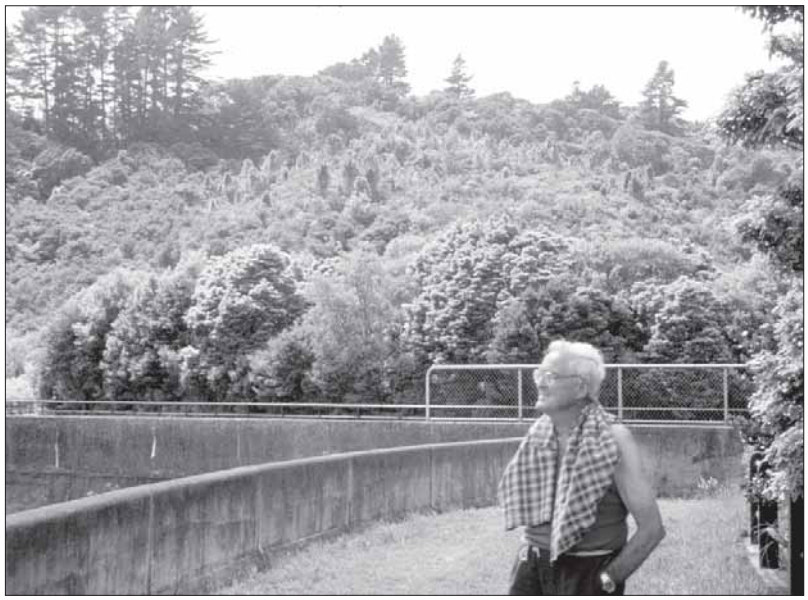
Using native plants in Canterbury. Canterbury Regional Council (undated[1]). *[Pamphlet, available from Environment Canterbury – outlines selecting and obtaining native plants, site preparation, planting, keeping a diary and maintenance]*

11. Restoration case studies

These examples are mostly from Canterbury, and cover a range of ecosystems involving community groups, individuals, local authorities and DOC. They provide a check on restoration theory and the methods used should be applicable throughout New Zealand.

Restoration of Tiritiri Matangi Island, in the Hauraki Gulf, is an outstanding success. Substantial native habitat has been restored, enhancing natural recovery. This has created a sanctuary for endangered birds, including saddlebacks/tieke, bellbirds/korimako, stitchbirds/hihi and takahē. The island is accessible to the people of Auckland, and the project has gained massive community support.

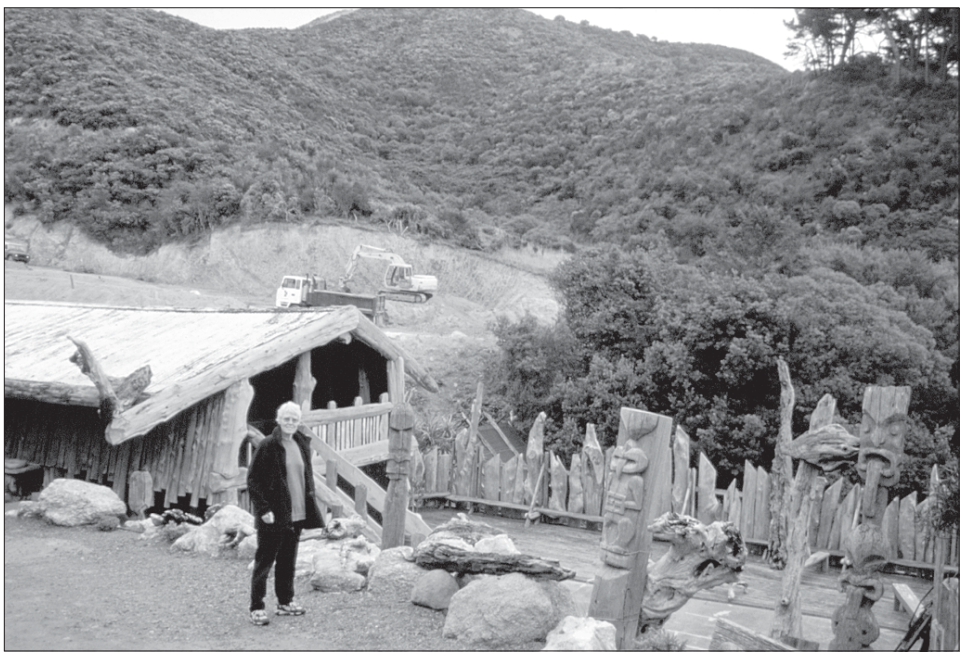
Contact: DOC, Auckland Conservancy.



Large areas of native forest were planted on bare slopes in the Hunua Range in the 1970s to mask the scars caused by the construction of reservoirs for the Auckland water supply. Brian McClure, one of the pioneers of large-scale forest restoration, is standing on the Mangatangi Dam, with 20-year-old, 12-m tall forest beyond.

Contact: Auckland Regional Council.

Mike Greenwood is one of the pioneers of ecological restoration in New Zealand with his major effort at Keebles Bush, Manawatu. With the help of conservation groups, he has controlled weeds such as wandering willie, buffered existing remnants, recreated new forest and propagated locally rare species and planted them back into the habitat. This view of podocarp forest at his home in Palmerston North, is the result of 40 years' labour.



The Tapu Te Ranga Marae, Wellington is the focal point for a major landscape restoration project to attract native birds back into the area, and provide resource materials for local iwi and the wider community. Maggy Wassilieff has been involved in the planning and design of this project.

Contact: Tapu Te Ranga Marae, Island Bay, Wellington.

Ōtukaikino is a partnership project between DOC (statutory landowners and managers), Lamb & Hayward (Funeral Directors) and the Ngāi Tuahuriri Rūnanga. The project is restoring a native podocarp swamp forest and wetland, and at the same time providing a living memorial. Willows are being used as a nursery for underplanting the first stages of new forest.

Contact: DOC, Canterbury Conservancy.

Excessive removal of weeds can create more problems than it solves. At Ōtukaikino, large-scale cutting of willow has resulted in the regeneration of young willow, blackberry and grass, which is hard to manage and interplant. The shade of the original mature willows suppressed willow and other weeds, and acted as a nursery for native planting.

Management of raupō in the open water areas of Ōtukaikino has become an issue since the wetland has been opened up by willow removal. Local iwi may be interested in harvesting surplus raupō for cultural uses – this would also assist in maintaining a mosaic of open wetland communities.

Travis Wetland Nature Heritage Park in Christchurch is the largest urban freshwater wetland in the country. The many restoration issues are managed by the Christchurch City Council in partnership with the community-based Travis Wetland Trust.

Contact: Christchurch City Council, Parks & Waterways Unit.

Grey willow, a rampant seeder that spreads across ungrazed open wetlands at Travis Swamp, is being eliminated. The more restrained crack willow (which spreads vegetatively, usually only along waterways) can be used as a nursery for future swamp forest species. Its deciduous canopy is an ideal nursery for this light-demanding but competition-shy kahikatea seedling, which was planted by a Forest and Bird group.

Field trials in the Ti Kōuka project, near Amberley Beach, North Canterbury. The project aims to mitigate the effect of sand mining in these stony beach ridges, enhance the remaining vegetation remnants and develop new wetlands. The site has been ripped and pre-sprayed with glyphosate. One trial used rabbit fencing to protect early growth of sensitive plants, while another used sleeves to protect plants. Plantings were done in spring and autumn, but only the spring plantings were irrigated – this nullified the usefulness of the irrigation trials.

Contact: Lucas Associates, Christchurch.

Existing tall vegetation and microsites, such as this macrocarpa tree on the edge of a wetland, are used in the Ti Kōuka project to establish frost-tender species. Their seed will later disperse into other parts of the site, once the hardy pioneers have formed a canopy and receptive litter beds. Plant protectors and animal repellents provided good protection on these unfenced sites, aided by leaving some areas

Waterway enhancement on Corsers Stream, Christchurch. This was the first such project for the Christchurch City Council 10 years ago. This stream drains from Travis Swamp into the Avon River. Sedges, rushes, trees and shrubs are now regenerating naturally on its banks. It provides an attractive walk, though some property owners miss seeing the water.

This grassy playing area, next to a 1950s ‘native garden’ at Thorrington School, Christchurch has developed into an extension of the bush garden after 10 years. A fence provides some security against unwelcome visitors. The native area will provide an educational resource for generations to come, especially if it is monitored.

This native habitat development at Cannon Hill Park, Christchurch was recognised by a Landcare Research award for sustainable management. Each residential section is covenanted and planted with native trees, shrubs and tussocks according to the different site conditions. Irrigation has allowed rapid establishment, but it has also resulted in rampant grass growth that chokes and hides small plants, making them vulnerable when weeding. Neighbouring sheep have escaped into some blocks, destroying plants and setting back by several years the objective of achieving dense forest cover. It is important not to underestimate the threat from domestic stock, and to allow a budget for maintenance.

At Cannon Hill Park, silver tussock/wi borders a young woodland of native trees.

Contact: c/- 2A Cephas Close, Upper Riccarton, Christchurch.

Ōtamahua/Quail Island is Christchurch's island restoration project. Community volunteers are being shown the correct planting technique. This needs repeated reinforcement as there is a risk of trees being poorly planted on large public planting days.

Contact: Ōtamahua/Quail Island Ecological Restoration Trust, PO Box 127, Lyttelton.

The 1050 ha Hinewai Reserve near the eastern-most extremity of Banks Peninsula is one of the most successful private conservation initiatives in the country. The land was purchased in 1987 by the Maurice White Native Forest Trust, using trust money, public subscription and the Forest Heritage Fund. Hugh Wilson is the manager, and many other workers have been employed by the Trust over the years, together with numerous volunteers. The vision of the project is to restore a major peninsula catchment to near its pristine state. "Minimum interference management" has focused on vigorous control of introduced animals, promoting natural regeneration of podocarp and beech forest through nurseries of native kānuka and exotic gorse.

Contact: Hinewai Reserve, RD3 Akaroa.

Medbury, Culverden Basin - one of the few reserves of dry savannah-like woodland in New Zealand. The low trees are kānuka with occasional matagouri, and native grasses include fescue tussock and danthonia. There are also many small mosses and lichens and some rare herbs. Management requires a mix of sheep grazing to control exotic grasses, and retirement of some areas to permit natural succession and allow highly palatable native species to regenerate.

Contact: DOC, Canterbury Conservancy.

Kākahu Bush, South Canterbury was purchased by conservation trusts, with the aid of Lottery Board, Community Trust and private funding. This podocarp and secondary forest is being managed by excluding stock, trapping predators, controlling weeds, and looking after historic monuments and geological features. Public walking tracks and interpretation are also provided.

Another South Canterbury icon is Arowhenua Bush, which Fraser Ross and other local Forest and Bird members have worked in for over 20 years. Harsh conditions have meant slow progress. However, with the planting of locally raised seedlings, the use of tree protectors and occasional summer watering, this stand of isolated kahikatea and matai now has a layer of young canopy hardwoods.

Contact: Timaru Branch, Royal Forest & Bird Protection Society.

Otipua wetland restoration, Timaru. This project aims to reinstate a former estuarine ecosystem that was destroyed by stopbanking, drainage and reclamation. The work began with major excavation of the land to create some open water and allow tidal water movement. Already, exceptionally high bird counts have been recorded here.

Contact: Environment Canterbury, 75 Church St, Timaru.

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Appendix 1

INVASIVE WEEDS

The following invasive weeds are reproduced from a list compiled by Hugh Wilson for Banks Peninsula. He has grouped them into three categories of seriousness – A) very serious and should be removed, B) moderately serious and should be removed if possible, and C) potentially troublesome and should not be spread around – remove small infestations. Several other invasive weeds in the South Island and southern North Island have been added and classified as above. Regional councils in more northern areas should be contacted for information about weeds in their regions. Auckland Regional Council (web site: http://www.arc.govt.nz, phone 0800 80 60 40), and Environment Waikato (web site: http://www.ew.govt.nz, phone 0800 800 401) both have numerous weed pamphlets and fact sheets that would be applicable to much of the North Island.

The ecosystems threatened by each weed are indicated by F (forest and shrubland), G (grassland, cliffs and riverbed, which may include a shrub component), C (coastal dunes or banks), and W (wetlands and riverbanks). **Note:** some shade-intolerant woody weeds may act as nurseries for native regeneration or later planting e.g. gorse, broom, flowering currant, elderberry, Montpellier broom, tagasaste, and crack willow.

A category		
Botanical name	**Common name**	**Ecosystem threatened**
Acer pseudoplatanus	sycamore	F
Asparagus asparagoides	smilax	F
Berberis darwinii	South American barberry	F, C
Bidens frondosa	beggar's tick	W
Clematis vitalba	old man's beard	F
Galeobdolon luteum	aluminium plant	F
Hakea spp.	hakeas	G
Hedychium gardnerianum	yellow ginger	F, W?
Iris pseudacorus	yellow flag iris	W
Lonicera japonica	Japanese honeysuckle	F
Lythrum salicaria	purple loosestrife	W
Passiflora mollissima	banana passionfruit	F
Passiflora pinnatistipula	passionfruit	F
Phalaris arundinacea	reed canary grass	W
Salix cinera	grey willow	W
Selaginella kraussiana	creeping spikemoss	F
Spartina anglica	cord grass	W (saline)
Tradescantia fluminensis	wandering willie	F
B category		
Alnus spp.	alders	W,G (mountains)
Athyrium filix-femina	female fern	W,F
Berberis glaucocarpa	barberry	F, C
Betula pendula	silver birch	G, W
Carpobrotus spp.	African iceplants	C
Cotoneaster simonsii	khasiaberry	F, G
Dryopteris filix-mas	male fern	F
Egeria densa	egeria	W
Elodea canadensis	Canadian pondweed	W
Hedera helix	ivy	F
Ilex aquifolium	holly	F
Lupinus x *polyphyllus*	Russell lupin	G
Lycium ferocissimum	boxthorn	C, G

B category		
Botanical name	**Common name**	**Ecosystem threatened**
Nasella trichotoma	nasella tussock	G
Pandorea pandorana	wonga wonga vine	F
Pinus radiata	Monterey pine	G, C
Polypodium vulgare	common polypody (fern)	G (rock bluffs)
Prunus avium	wild cherry	F, G
Prunus cerasifera	cherry plum	F
Prunus laurocerasus	cherry laurel	F
Rubus fruticosus agg.	blackberry	F, W
Salix fragilis	crack willow	W
Senecio angulatus	Cape ivy	F
Senecio mikanoides	German ivy	F
Solanum mauritianum	woolly nightshade	G, F
Tropaeolum speciosum	Chilean flame creeper	F
Vinca major	periwinkle	F
Zantedeschia aethiopica	arum lily	W
C category		
Acaena agnipila	Australian bidibidi	G
Actinidia deliciosa	kiwifruit	F
Ammophila arenaria	marram grass	C
Arrhenatherum elatius	tall oat grass	G, W
Buddleia davidii	buddleia	G, C
Calluna vulgaris	ling heather	W, G
Carex flacca	blue/carnation sedge	W
Carex ovalis	oval sedge	W
Chamaecyparis lawsoniana	Lawson cypress	G?
Chrysanthemoides monilifera	boneseed/saltbush	C, G
Cortaderia jubata	pampas grass	G, C
Cortaderia selloana	pampas grass	G, C
Cotoneaster franchetii	cotoneaster	G, F
Cotoneaster glaucophyllus	cotoneaster	G, F

C category		
Botanical name	**Common name**	**Ecosystem threatened**
Cotoneaster horizontalis	cotoneaster	G, F
Cotoneaster lacteus	cotoneaster	G, F
Cotoneaster microphyllus	cotoneaster	G, F
Crataegus monogyna	hawthorn	G, F
Cupressus macrocarpa	macrocarpa	C
Cyperus eragrostis	umbrella sedge	W
Cytisus scoparius	Scottish broom	G
Erica lusitanica	Spanish heath	G
Erigeron karvinskianus	Mexican daisy	G
Euonymus europaeus	spindleberry	F
Festuca arundinacea	tall fescue	W, C, G
Fraxinus excelsior	ash	F
Glechoma hederacea	ground ivy	G (rocky)
Gunnera manicata	Brazilian rhubarb	W
Gunneral tinctoria	Chilean rhubarb	W
Hieracium spp.	hawkweeds	G. *H. lepidulum* (F)
Holcus lanatus	Yorkshire fog	W, G
Jasminum officinale	jasmine	F
Larix decidua	larch	G
Leycesteria formosa	Himalayan honeysuckle	F
Ligustrum vulgare	privet	F
Lotus pedunculatus	lotus	W
Lupinus arboreus	tree lupin	C, G
Pseudotsuga menziesii	Douglas fir	F, G
Rhamnus alaternus	evergreen buckthorn	F, C
Ribes sanguineum	flowering currant	F
Sambucus nigra	elderberry	F
Sedum acre	stonecrop	G, C
Teline monspessulana	Montpellier broom	G, C
Ulex europaeus	gorse	G, W, C