SOUTH ISLAND
WILDING CONIFER
STRATEGY

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CONTENTS

1. Overview

The uncontrolled spread of introduced conifers (wilding conifers) presently threatens over 210,000 hectares of land administered by the Department of Conservation (DOC) in the South Island. Wilding conifers threaten native plant communities, endangered species, and important wildlife habitat. In some cases plant communities and species, such as bog pine shrublands, the rare *Hebe cupressoides* and the Cromwell chafer beetle, are threatened with local extinction. Wilding conifers also threaten the distinctive expansive landscapes of the South Island, historic and cultural sites, and recreation opportunities.

Wilding conifers are defined, for the purposes of this strategy, as introduced species of the Class Coniferopsida (Gymnospermae) that are self-sown or growing wild (i.e. naturalised). Typically wilding conifers have spread from planted trees, and these plantings often provide a continuing seed source for further wilding spread. Eighteen species of wilding conifer threaten DOC-administered land in the South Island, five of which comprise most of the spread (contorta pine, Corsican pine, Douglas fir, radiata pine and larch).

These wilding conifer species are characterised by their ability to disperse, and the vigour of their growth. They can produce cones at between eight and thirteen years of age, and produce vast quantities of seed that can be dispersed for distances of over 10 kilometres in favourable conditions. Wilding conifers are long-lived and can out-compete other plant species in nearly all communities except dense forest. Dense infestations will reduce water yield from stream catchments, reduce the profitability of pastoral farming, restrict access for recreation, and transform scenic landscapes.

There are at least 245 DOC-administered sites threatened by wilding conifer spread in the South Island, from regenerating native forest in the Marlborough Sounds to dunes on Stewart Island, and from estuary margins on the West Coast to areas above the natural timberline in the eastern Southern Alps. The Department spent at least $236,000 and 3686 hours of staff time controlling wilding conifer infestations in the South Island in the 1999/2000 financial year. An additional $112,000 has been allocated to new wilding conifer control projects in the 2000/2001 financial year. Not all infestations are controlled as, at present, there are insufficient funds to do so. If wilding conifer control was neglected for just a few years many important conservation sites would be damaged beyond repair and the cost of removing new infestations would rise exponentially.

This strategy covers all wilding conifer spread that threatens DOC-administered land in the South Island. The purposes of the strategy are to describe the present wilding conifer problem, to outline the conservation values at risk from wilding conifer spread, to identify the Department's wilding conifer control obligations, and to propose options for the control of wilding conifers. Control priorities proposed have been determined using the methodology of Department's Strategic Plan for Managing Invasive Weeds. The strategy is compatible with the Department's Conservation Management Strategies and with Area Weed Strategies.

Wilding conifers affect large parts of the South Island, are the most significant weed threat in many areas, and do not discriminate between land tenures and property boundaries. Control of wilding conifers must be targeted at the most important sites, coordinated between land management agencies and landowners, and be sustained for as long as there is a risk of re-infestation. This Wilding Conifer Strategy aims to help ensure that this will occur.

2. The wilding conifer problem

2.1 WILDING CONIFERS IN THE SOUTH ISLAND

The present extent of wilding conifer spread

Wilding conifer spread is present in nearly all regions of the South Island. The most extensive areas of spread are in the inter-montane basins and ranges of the high country where grassland or shrubland ecosystems dominate. However, wilding conifer spread also affects regenerating forest and shrubland in coastal areas, open plant communities on mineralised (ultramafic) rock, and areas above the natural timberline.

The total area of DOC-administered land in the South Island threatened by wilding conifer spread[i], as estimated during the preparation of this strategy, is approximately 210,000 hectares. Wilding conifers threaten over 245 DOC-administered sites, from regenerating native forest in the Marlborough Sounds to dunes on Stewart Island, and from estuary margins on the West Coast to areas above the natural timberline in the eastern Southern Alps. Among the largest areas threatened are the Red Hills Range in Marlborough (12,000 hectares), the Ferintosh Retirement Area in the Mackenzie Basin (15,000 hectares), Mt Aurum in Otago (5,000 hectares), and the Mid Dome and East Dome area in Southland (over 8,000 hectares).

The total area threatened by wilding conifer spread in each Conservancy is approximately 72,000 hectares in Nelson/Marlborough, 60,000 hectares in Canterbury, 64,000 hectares in Otago, 16,000 hectares in Southland, and just 200 hectares in the West Coast Conservancy. These totals do not include recommended areas for protection (RAPs) on Molesworth Station in Marlborough (26,000 hectares) that are not administered by DOC, but where the Department undertakes wilding conifer control. Neither do the totals include some areas of pastoral lease land where the Department undertakes wilding conifer control to protect important conservation values. These areas are listed separately in Appendix 2 of this strategy.

The precise extent of wilding conifer spread is difficult to quantify, as many areas have not been adequately or recently surveyed for the presence of wilding conifers. Large areas can be quickly colonised by wilding conifers as a result of one significant dispersal event, such as that resulting from strong winds while trees are coning. And, wilding conifer infestations range from dense stands near seed trees to distant spread where single seedlings are scattered at low densities over a wide area.

Wilding conifer spread is not confined to DOC-administered lands in the South Island. However, the total area affected by wilding spread in the South Island is unclear, largely because comprehensive surveys of wilding spread have not been undertaken. A survey of 2.2 million hectares of high country land (of all tenures) within the Canterbury Region during 1989/1990 identified 510 separate wilding spread locations covering 17,500 ha (0.8%) of the area[1]. However, one of the largest areas of wilding spread in Canterbury – over 8,000 ha on the Amuri Range[2] – was not covered by that survey. Also, the survey only recorded areas already affected, rather than threatened, by wilding conifers.

[i] *The area likely to be affected within 15 years if no control is undertaken*

A summary of wilding conifer spread in each Conservancy

- Nelson/Marlborough Conservancy

Wilding conifers threaten over 72,000 hectares of DOC-administered land at 51 sites within the Nelson/Marlborough Conservancy. Three main types of wilding conifer spread are present[3]. Radiata pine threatens a large number of smaller reserves containing areas of shrubland and regenerating forest in the Marlborough Sounds and along the Abel Tasman National Park and Golden Bay coastlines. Several conifer species, though predominantly contorta pine, threaten shrubland, tussockland and rockland plant communities on ultramafic rock in the Richmond Range and Red Hills area[4]. And, several conifer species threaten large areas of montane and subalpine tussockland, herbfield and rockland at Waihopai, Ferny Gair, and in the Branch and Leatham catchments in south Marlborough. Substantial areas recommended for protection, though not administered by DOC, on Molesworth Station are also threatened by wilding conifer spread.

- West Coast Conservancy

Wilding conifers threaten approximately 200 hectares of DOC-administered land at 14 separate sites in the West Coast Conservancy. At the most important site contorta, radiata, and mountain pine threaten an area of shrubland, *Chionochloa juncea* tussockland, rockland, and great spotted kiwi habitat on the Denniston coal plateau. The most extensive areas affected are successional shrublands on lowland outwash terraces near Charleston that are being invaded by radiata pine. Coastal dunes, estuaries and the margins of lowland forest reserves are also threatened by small infestations of wilding conifers.

- Canterbury Conservancy

Wilding conifers threaten over 60,000 hectares of DOC-administered land at 102 sites in the Canterbury Conservancy. The most extensive affected areas lie within the montane basins and ranges of the 'high country' east of the main divide of the Southern Alps. There are several infestations, each covering several thousand hectares, throughout the Canterbury high country from the Clarence Valley in the north to the Kirkliston Range in the southeast. Corsican pine, contorta pine, Douglas fir and larch form the largest areas of spread, but several other wilding conifer species are also important. Smaller areas of wilding radiata pine spread are present in reserves on Banks Peninsula, and a range of wilding conifer species threaten reserves in the foothills east of the Canterbury Plains. Several plant communities, such as bog pine (*Halocarpus bidwillii*) shrublands, and species, such as *Hebe cupressoides*, are threatened with local extinction by wilding conifer spread in Canterbury.

Wilding conifer spread is not restricted to the South Island. Over 30,000 hectares on the North Island's volcanic plateau were affected by wilding contorta pine in 1975[5]. Wilding conifers also affect indigenous ecosystems in at least six other countries in the temperate climatic zone of the Southern Hemisphere, including over 325,600 hectares of fynbos shrubland in South Africa, and areas of open eucalypt forest in several parts of Australia[6].

- Otago Conservancy

Wilding conifers threaten over 64,000 hectares of DOC-administered land at 65 sites in the Otago Conservancy. As in Canterbury, the most extensive areas affected are the inland montane basins and ranges, where wilding conifers threaten tussockland, shrubland, and herbfield. The most widespread species are Douglas fir, contorta pine, larch, and Corsican pine, but most other wilding conifer species are also present. Douglas fir poses a significant threat to beech forest and tussocklands in the Queenstown area, and larch and contorta pine are prominent elsewhere in the Otago high country. Coastal and lowland reserves are also affected by wilding

spread in Otago. Radiata pine and macrocarpa are the most common species, though most infestations are relatively small. Extensive areas of open country in the Eyre Mountains, Remarkables Range, and other mountain ranges are presently unaffected, but potentially threatened, by wilding conifer spread.

- Southland Conservancy

Wilding conifers threaten over 16,000 hectares of DOC-administered land at 19 sites in the Southland Conservancy. The most extensive area of wilding spread is at Mid Dome in northern Southland where contorta pine and several other wilding species threaten over 4,000 hectares of DOC-administered land and a further 13,000 hectares of other land. Several other important sites in the Blue Mountains, southern Eyre Mountains, and Takitimu Range are threatened, but still relatively unaffected by, wilding spread. Radiata pine and macrocarpa threaten several important lowland and coastal sites in mainland Southland and Stewart Island. These sites include the extensive dunelands at Mason Bay, skink habitat at Martins Bay and Big Bay, and the extensive wetlands at Waituna.

Rare plant species and communities are threatened by wilding conifer spread in all Conservancies. Ultramafic vegetation is threatened in Marlborough. Great spotted kiwi habitat is threatened on the West Coast. Populations of rare shrubs and invertebrates are threatened with local extinction in Canterbury and Otago. And, bog pine shrublands are threatened with local extinction by wilding spread in Southland. The most critical biodiversity values threatened by wilding conifers are listed in section 3.1.

Wilding conifer spread also affects substantial areas of Crown-owned land leased for pastoral farming (pastoral lease land) in the eastern South Island high country. Significant areas of pastoral lease land are likely to be administered by DOC once the present process of tenure review has been completed. This will increase the number of wilding conifer infestation sites, and the area of wilding conifer spread, for which the Department will be responsible. Also, the removal of domestic stock from retired pastoral lease land will remove one of the main wilding conifer control agents – grazing sheep – and may allow wilding conifer seedlings to establish more readily.

Wilding conifer species

At least 25 introduced conifer species are regarded as naturalised (i.e. growing wild) in the South Island of New Zealand[7]. However some of these species are only sparingly naturalised, growing wild in just a few locations or covering only a very small area. Other introduced conifers may never become naturalised or, if naturalised, may never pose a significant threat to indigenous ecosystems. For example, at least ninety introduced conifer species have been planted at Craigieburn in the Canterbury high country since 1954, yet only seven of these species had become naturalised at that site by 1988[8].

Naturalised conifers were first recorded in New Zealand about 100 years ago, but significant areas of spread were not observed until the 1950s. Additional introduced conifer species are likely to become naturalised as further seed sources (planted trees) mature or as a result of changes in the management of surrounding land.

*There are 105 existing species of pines (*Pinaceae *family) – just one of the conifer families. All except one of these species are confined, in their natural range, to the Northern Hemisphere[9]. Pines have been extensively planted in the Southern Hemisphere, with seven* Pinus *species forming the basis of the plantation forestry industry. Over 80* Pinus *species have been planted in South Africa, and over 29 species at one site in New Zealand (Craigieburn Range)*[6].

Naturalised conifers listed in the Department of Conservation's draft database of ecological weeds on conservation land are contorta pine, Douglas fir, maritime pine, and the catch-all '*Pinus* spp.'[10]. Eighteen wilding conifer species are identified in this strategy as posing a threat to DOC-administered land in the South Island:

Austrian pine ..... *Pinus nigra* ssp. *nigra*
big cone pine ..... *Pinus coulteri*
bishop pine ..... *Pinus muricata*
contorta pine ..... *Pinus contorta*
Corsican pine ..... *Pinus nigra* ssp. *laricio*
Douglas fir ..... *Pseudotsuga menziesii*
larch ..... *Larix decidua*
Lawson's cypress ..... *Chamaecyparis lawsoniana*
macrocarpa ..... *Cupressus macrocarpa*
maritime pine ..... *Pinus pinaster*
mountain pine ..... *Pinus mugo* and *P.uncinata*
Norway spruce ..... *Picea abies*
Ponderosa pine ..... *Pinus ponderosa*
radiata pine ..... *Pinus radiata*
redwood ..... *Sequoia sempervirens*
Scots pine ..... *Pinus sylvestris*
Sitka spruce ..... *Picea sitchensis*
western red cedar ..... *Thuja plicata*

Nomenclature follows Webb, Sykes, and Garnock-Jones (1988)[7]

The species comprising the most extensive areas of wilding spread are contorta pine, Corsican pine, Douglas fir, radiata pine and larch. Other important species are Scots pine, mountain pine, Ponderosa pine and macrocarpa.

2.2 CHARACTERISTICS OF WILDING CONIFER SPREAD

Characteristics of invasive introduced conifers

Wilding conifer species are, by definition, invasive. The significant characteristics that set these invasive species apart from non-invasive introduced conifers are early maturing (coning), small seeds, and frequent large seed crops[6].

The invasiveness of wilding conifer species can, to some extent, be predicted by their biological success rating (BSR). This rating measures the biological capacity of a species based on criteria such as age of seeding, quantity of seed produced, viability of seed, seed dispersal, seedling establishment and growth rates. Wilding conifer species have been given BSR scores of 12 (highest) to 10 (lowest)[10]. For example, contorta pine scores 12, and Douglas fir 10. By comparison, old man's beard has a BSR score of 15, gorse scores 14, and elder ('elderberry') scores 10.

The BSR scores for wilding conifer species in the South Island were re-assessed during the preparation of this strategy (See Page 43). Five species were given a score of twelve (larch, contorta pine, mountain pine, Corsican pine, Scots pine), four species a score of eleven (bishop pine, maritime pine, radiata pine, Douglas fir), and eight species given a score of ten (Lawson's cypress, macrocarpa, Norway spruce, Sitka spruce, big cone pine, Ponderosa pine, redwood, western red cedar).

The spreading vigour of wilding conifer species has also been assessed, based on species' competitiveness, palatability, seed production, and seed weight[13]. The spreading vigour of the species, in order from most vigorous to least vigorous, is:

contorta pine → Scots pine → mountain pine → Douglas fir → Corsican pine → larch → Ponderosa pine → muricata pine → radiata pine

Different provenances (regional variations) of introduced conifer species may differ in their spreading vigour. For example, the 'Washington coastal' provenance of contorta pine has coned and spread more vigorously than the 'Californian coastal' provenance where both have been planted or sown in inland Marlborough[11]. Site conditions, especially altitude and climate, also influence the spreading vigour of wilding conifers.

Factors influencing wilding spread

Whether invasive wilding conifer species will, in fact, invade is determined by a range of other factors, including:

- Presence of seed sources;
- Siting and management of plantings (seed sources);
- Direction, severity and frequency of strong winds;
- Composition and stature of the plant communities on surrounding land;
- Presence of mycorrhizal symbionts (fungi) on surrounding land;
- Resistance to pests and diseases;
- Palatability of the wilding species;
- Site conditions (including climate);
- Management of surrounding land (including disturbance).

The presence of a seed source is an obvious requirement for wilding spread. Many conifer species have been planted for amenity purposes, soil stabilisation, or as plantations throughout the South Island. In some places, such as the Branch and Leatham catchments in Marlborough, introduced conifers were sown from aircraft. As more planted or sown trees mature, and more species are planted, the amount

and distribution of viable seed sources will increase. Selection of non-invasive species for future plantings will help limit the risk of wilding spread.

The siting of planted trees is an important determinant of wilding spread. Trees planted at exposed sites, particularly ridge-top "take-off" sites, are more likely to produce wilding spread than trees planted at sheltered sites. Orientation of plantations with the longest axis at right angles to the prevailing wind may also increase the likelihood of wilding spread[13]. Plantation design may influence wilding spread. Large plantations, and plantations with a large boundary to area ratio, are more likely to produce wilding spread[6]. However, planting non-invasive species around plantation margins may reduce this risk[13].

All South Island wilding conifer species have wind-dispersed seed, though one naturalised species – strobus pine – has vertebrate-dispersed seed[6]. Wilding spread is typically downwind from seed sources, to the extent that the direction of spread can often be predicted from the direction of the prevailing wind. However, spread can be in any direction. A notable example of this is the northerly spread of wilding conifers from plantations at Hanmer into the Clarence River valley (North Canterbury). This spread against the prevailing northwest winds is attributed to a single southerly storm, possibly the Wahine storm, in the late 1960s[1].

Strong winds can transport seed for many kilometres. Wilding conifer spread has been recorded 40 kilometres from the seed source at Mid Dome (Southland)[12], and wildings frequently establish at least 10 kilometres from parent trees. Seed is usually deposited at sheltered sites, such as lee slopes, where wind speed is reduced.

Of the common wilding conifers, contorta pine and mountain pine mature earliest, producing viable seed at eight years of age at favourable sites. Radiata pine and maritime pine can produce viable seed at 10 years of age; Scots pine, Douglas fir, larch, and muricata pine at 12 years; and, Corsican pine and Ponderosa pine at 13 years of age[13]. There is further anecdotal evidence that some of these species can produce seed at a much younger age at some sites.

The successful germination and establishment of wilding conifer seed may depend on the composition of plant communities at the site. Bare ground, or low stature plant communities such as grassland (including tussockland) and herbfield, are the most favourable communities for wilding establishment. Shrubland is relatively less favourable, and forest generally unfavourable. However Douglas fir, which is relatively shade-tolerant, may establish beneath a mature beech (*Nothofagus* sp.) forest canopy[14], and other wilding species may establish in openings within regenerating forest.

The presence of symbiotic mycorrhizal fungi in the soil may also influence the establishment of wilding conifers. The absence of such fungi prevented the successful establishment of introduced pines in several parts of the Southern Hemisphere, though it is likely that the appropriate mycorrhizal symbionts are now present throughout the South Island[6].

Resistance of introduced conifer species to pests and diseases may also affect wilding establishment and success. For example, in trials at Craigieburn, spruces (*Picea* spp.), Scots pine, and mountain pine were prone to damage by aphids[8], and in some South Island plantations Corsican pine was less affected than Ponderosa pine by several pests and diseases[16].

The presence of wild or domestic animals and the palatability of introduced conifer species are likely to influence the successful establishment of wildings. Sheep can prevent the establishment of wilding conifers on intensively grazed land and reduce wilding spread on extensively grazed lands[18]. Cattle can reduce wilding growth but rarely kill seedlings, and may enhance wilding establishment by reducing tussock and shrub cover[12]. Fluctuating rabbit numbers and the retirement of land from

grazing has contributed to wilding spread in the Mackenzie Basin[15], and possum or hare browse may prevent wilding establishment or hinder plant growth[6].

The environmental conditions at the site, notably soils, altitude and climate, will affect wilding establishment and growth. Large variations in growth rate between species of introduced conifers growing at different sites were recorded by 30 years' research in the Craigieburn Range (Canterbury)[8]. A temperate climate, such as that of the South Island, is favourable for wilding conifer growth[6], and rainfall is one of the more important factors influencing growth rates with trees growing significantly better in higher rainfall areas[16], though coning earlier in drier areas[17]. Low temperatures, especially frosts, can affect the successful establishment of some wilding conifer species. Most lowland and montane parts of the South Island were, until relatively recently, entirely forested. These areas continue to provide favourable sites for wilding conifer establishment. And, some wilding conifer species can grow successfully above the natural timberline for native species.

The mortality of seedlings of seven introduced conifer species in browsing trials was relatively low, with radiata pine being the most palatable (34% mortality after one year), and Corsican pine the least palatable. The species, in order of most to least palatable were: radiata pine → Ponderosa pine → contorta pine → larch → Scots pine → Douglas fir → Corsican pine[18].

The successful establishment and growth of wilding conifers is also dependent on land management at the site. Intensive grazing, cultivation, or burning is likely to reduce wilding conifer establishment. Deliberate mob-stocking of areas threatened by wilding spread may help prevent seedling establishment, though it may also hinder control once seedlings are established and may threaten biodiversity values. Light grazing or burning may encourage the spread of wilding conifers by reducing competition from palatable plant species or creating open sites for the seedlings of wilding conifers to establish. Regular checking as part of routine land management may enable simple control, such as the removal of outlier trees or seedlings, to be undertaken at little cost.

Mechanics of wilding spread

The main wilding conifer species present in the South Island, produce significant quantities of viable seed from between eight and thirteen years of age. The onset of coning and seed production is influenced by the severity of the environment[17] and varies from year to year. Most seed is released in autumn and winter when cones are opening and much of this seed is deposited near the parent tree. Seed remains viable in the soil for about three years, though can remain viable in cones for much longer[12].

Most wilding conifer seedlings establish, if conditions are favourable, close to the parent tree forming *fringe spread*. If seed is released during strong wind seedlings may establish many kilometres away from the parent tree, forming *distant spread*. As the fringe spread grows it typically forms a dense stand of trees around the parent tree, and as the distant spread grows it typically forms scattered *outlier trees*. When these outlier trees mature they, in turn, may produce further fringe or distant spread.

A typical wilding conifer infestation in open country will comprise a dense cluster of trees around the original parent tree and scattered outlier trees, each with its own cluster of fringe spread, scattered downwind of the original parent tree. However, many factors may influence the spatial distribution of spread, especially where significant barriers to establishment and growth are present.

A significant feature of wilding conifer spread is the number of new locations at which seedlings may establish at one time, especially if seed is dispersed over long distances by strong wind. This increase in the number of new infestation sites, in turn, dramatically increases the area at risk from further spread[19]. Outlying trees represent the invasion front. The removal of these trees before they produce seed is often the most important control priority.

Radiata pine is by far the most widespread wilding conifer species. It is present at over half (128) of the 244 wilding conifer infestation sites that threaten DOC-administered land in the South Island. Contorta pine and Douglas fir are each present at about 25% (60) of the sites, larch at 16% (40) and Corsican pine at about 14% (35) of the infestation sites. Ponderosa pine (7% of sites), macrocarpa (7%), mountain pine (5%) and Scots pine (5%) are also relatively common. Note that more than one wilding conifer species is present at many sites, and that at 15% of sites at least one of the wilding conifer species is presently unidentified.

2.3 PRESENT CONTROL EFFORT

A significant proportion of the Department of Conservation's annual budget is expended on weed control. The proportion of this expenditure that is allocated to wilding conifer control is difficult to quantify, as wilding conifers are controlled as part of 'site-led' control programmes, where a range of weed species are controlled to protect the biodiversity values of the site. No wilding conifers are presently controlled under 'weed-led' control programmes in the South Island, where a particular weed species is targeted.

However, there are several major ongoing site-led weed control programmes where wilding conifers are the only, or main, species controlled at that site. The cost of these programmes in the five South Island Conservancies during the 1999/2000 financial year was $236,200 in operating expenditure plus 3686 hours of staff time.

Present Costs of Wilding Conifer Control in the South Island:
(1999/2000 financial year)

Conservancy	**Operational ($)**	**Labour (hours)**
Nelson/Marlborough	35,000	980
West Coast	nil*	nil*
Canterbury	100,000	1,200
Otago	46,800	1,150
Southland	54,400	356
Total	**236,200**	**3,686**

**The West Coast Conservancy has no specific wilding conifer control programmes, although wilding conifers are controlled as part of other site-led weed control programmes.*

Of the 117 wilding conifer infestations at sites with total score (biodiversity x urgency) score of 12.5 or more, listed in the schedule in Appendix 1, approximately 80 (68%) are presently funded for control. All sites scoring 21 or 18 are funded. Twenty-two (85%) of the twenty-six sites scoring 15, and approximately fifty-three (62%) of the eighty-six sites scoring 12.5, are funded for control.

2.4 POTENTIAL EXTENT OF THE WILDING CONIFER PROBLEM

Wilding conifers, if uncontrolled, will eventually invade and dominate almost all low-stature plant communities (rockland, herbfield, grassland, and shrubland) at montane and lowland sites on DOC-administered lands in the South Island. Wilding conifer seed sources are present in nearly all areas of the South Island. Wilding conifers are aggressive and rapid invaders of open land. And, low-stature native plant communities offer little resistance to wilding conifer establishment.

Whether such a situation would occur within 50 years, or over a longer period, is difficult to predict as the rate of spread and vigour of wilding conifers varies widely between species and sites. However, strong winds occurring as cones open could disperse wilding conifer seed over thousands of hectares. Then, it may be only eight years, depending on the species and site, before those newly-established wilding trees mature to produce cones themselves.

Any failure to undertake wilding conifer control, or lapse in an existing control programme, coinciding with such a spread event may eventually cost the Department many hundreds of thousands of dollars in future wilding conifer control or may lead to the loss of native plant communities over a wide area.

The implications of doing nothing – an example

The Red Hills area in Marlborough comprises approximately 12,000 hectares of open ranges, all lying below an altitude of 1790m. The area is made up of ultramafic rock, and supports plant communities and species that are endemic to the area. The whole area lies downwind of extensive areas of plantation forest, and is threatened by wilding conifer spread from these forests and from established wilding conifer infestations nearby.

Containment of spread in the vicinity of these established forests, and continued removal of scattered outlier wildings from the Red Hills, is estimated (in 1996) to cost $2,500 initially and then $18,000 every five years[4].

If control were not undertaken for 25 years, there would be an opportunity for three generations of the main wilding conifer species present (contorta pine) to establish, assuming that the trees mature and cone within eight years. The first generation of spread would probably disperse seed over most of the 12,000 hectares within ten years (discounting wildings that may establish from seed already dispersed).

Spread from these newly-established wildings (the second generation) would probably colonise any remaining unaffected parts of the Red Hills, and would create dense fringe spread around the seed trees. The third generation of spread would increase the number of clusters of fringe spread and increase the density of outlier spread.

Assuming there was no wilding conifer control for 25 years the following scenario is possible:

- *25% (3,000 ha) of the area covered with lightly scattered outlier trees (<100 stems/ha);*
- *40% (4,800 ha) of the area covered with occasional outlier trees (100 to 500 stems/ha);*
- *25% (3,000 ha) of the area covered with frequent outlier trees (500 to 2000 stems/ha);*
- *10% (1,200 ha) of the area covered with denser fringe spread (>2,000 stems/ha)*

*The cost of wilding conifer removal in this situation could be as much as **$2.5 million***, (not including follow-up control) compared with **$90,000** over the same period if wilding conifer control is continued ($18,000 every 5 years). Note that these figures are not adjusted for inflation.*

**(3,000 ha @ $55/ha = $165,000; plus 4,800 ha @ $150/ha = $720,000; plus 3,000 ha @ $300/ha = $900,000; plus 1,200 ha @ $600/ha = $720,000)*

3. Conservation values at risk

3.1 THE EFFECT OF WILDING CONIFER SPREAD ON ECOLOGICAL VALUES

The most obvious effect of wilding conifers is visual. However, wilding conifer spread affects more than just visual or landscape values. Introduced conifers can have a significant effect on native plant and animal communities, species, soils, and water yields. They can also affect land uses such as pastoral farming and recreation. These effects are discussed below.

Effects on plant communities

The most obvious ecological effect of wilding conifers is their ability to invade and suppress low-stature plant communities. The relatively fast growth rates of the introduced conifers, and the ability of some species to grow at harsher sites and at higher altitudes than native woody species, allows wilding conifers to out-compete and suppress native vegetation. This is the most significant effect of wildings throughout most of the South Island high country, where the most widespread plant communities are grassland and shrubland.

In extreme cases wilding conifer spread may lead to the local extinction of plant communities. Native grassland and naturally stunted native shrubland communities on ultramafic substrates in the Red Hills-Hackett area of Nelson/Marlborough are threatened in this way by wilding conifer spread. Remnant shrubland and grassland communities in the intermontane basins of the South Island high country are threatened with local extinction by wilding conifers.

Wilding conifers can also alter the structure of intact native forest communities. Douglas fir seedlings will readily establish within native mountain beech forest, and have been recorded within beech forest at densities of over 80,000 seedlings per hectare[14]. Most seedlings will not persist beneath a dense forest canopy, but light gaps are frequently created in mature beech forest and may allow the successful establishment of Douglas fir trees. The ability of Douglas fir to invade beech forest is well illustrated on the slopes of Ben Lomond, Queenstown, and at Bealey Spur near Arthur's Pass.

The structure of shrubland and regenerating forest can also be affected by wilding conifers. Openings within these communities, and the low stature of the surrounding vegetation, allow the light-demanding wilding conifers to establish and out-compete native woody species. Large areas of regenerating forest and shrubland in the Marlborough Sounds are affected in this way, mostly by radiata pine. Site conditions (and wilding conifer control) will determine whether wilding conifers or the regenerating native forest will become dominant in the long term.

A further, secondary, effect on plant communities is the increased susceptibility to damaging fires. The presence of wilding conifers in non-woody plant communities may, in the event of wild fire, mean that fires burn longer and hotter than otherwise due to the presence of both dead and live wood. Some species of introduced conifer are well adapted to regenerate after fire.

Effects on individual species

The effects of wilding conifers may not be limited to plant community structure. Individual species may be displaced or habitat may be created for other species. Where low-stature plant communities are completely overwhelmed by wilding

conifer spread, local extinction of individual species may occur. Populations of species, such as *Hebe armstrongii* in the Waimakariri Basin, and *Hebe cupressoides* throughout the high country, are threatened with local extinction by wilding conifers.

Animal species may also be threatened by wilding conifer spread, notably native lizards and invertebrates in open communities, as the establishment of conifers can alter the habitat of existing species and create new forest habitat. Important examples are the Cromwell chafer beetle (*Prodontria lewisi*), threatened by wilding conifer spread at its only known location in the Clutha Valley, and the robust grasshopper (*Brachaspis robustus*), in the Mackenzie Basin (*see following page*). Freshwater fish populations may be affected by wilding conifer spread, through shading of streams or reduced water flows. Felling operations may cause a reduction on water quality.

Conversely, the establishment of introduced conifer forests can sometimes create useful habitat for native and introduced species. Several rare native orchid species are commonly found in conifer forests[20], and mature Northland pine plantations can provide habitat for North Island brown kiwi[21]. However, in general, fewer native bird species are found in plantation forests than in native forests[22]. And, invariably, the establishment of forests of introduced conifers leads to the displacement of native species and a net loss in biological diversity.

Effects on soils and hydrology

Other, perhaps less obvious, effects of wilding conifer spread are the effects on soils, nutrients, and hydrology. Wilding conifers in tussocklands take up and hold a larger pool of nutrients than the snow tussocks they replace[23], presumably through increased mineralisation of the soil organic matter or through nutrient transfer from deeper soil horizons[24]. It is possible that introduced conifers will accelerate acidification and eventual podzolisation of soils that formerly supported native forest, though there has been insufficient time to measure this possible effect in New Zealand[25].

Forest cover – native or exotic – may protect soils from some forms of erosion more effectively than either pasture or crops. Analysis of East Coast (North Island) slopes after Cyclone Bola indicated that the extent of slope failure under mature exotic plantations or regenerating indigenous scrub and forest, was only 10% of that under pasture[26]. Afforestation may reduce greenhouse gas emissions by storing carbon from the air and soil in the tree, and by reducing methane emissions through a reduction in livestock numbers[25]. However, if these are favoured objectives for DOC-administered land, they should be achieved through the regeneration of native shrubland and forest communities, not by the uncontrolled spread of wilding pines.

Introduced conifers can also affect water yield. Exotic plantations yield lower mean water flows and lower low flows than either native forest or pasture[27]. Pine planting on pasture and gorse covered hills in the Moutere Catchment (Nelson) reduced annual run-off by 55% and ground water recharge by nearly 70%[28]. And, research in the Mackenzie Basin predicted that the conversion of tussock grasslands to pine plantations would result in a 25-30% reduction in water yield[29]. This effect has significant implications for populations of in-stream flora and fauna, as well as water supplies for domestic and pastoral use.

Plant communities and species threatened with local extinction by wilding conifer spread:

Species or Community	Location and Area	Weed Species Present
Hebe armstrongii	Enys Reserve, Canterbury	larch, *Pinus* sp., broom, gorse, blackberry, *Hieracium pilosella*
Hebe cupressoides	Pukaki Scientific Reserve, Canterbury; Ferintosh Retirement Area, Canterbury; Lake Lyndon, Canterbury; Cave Stream Reserve, Canterbury	contorta pine, *Pinus nigra*, cotoneaster, *Nardus stricta*; larch, contorta pine, rowan, broom, and others; *Pinus* sp., sweet brier, herbaceous weeds; radiata pine?, broom, crack willow, blackberry, gorse and others
Uncinia strictissima	Shag Point Scientific Reserve, Otago	radiata pine, Douglas fir, macrocarpa, gorse, broom, cotoneaster
Leptinella nana and *Myosotis australis* var. *lytteltonensis*	Lyttelton Scenic Reserve, Canterbury	radiata pine, gorse, hawthorn, bone-seed, boxthorn and others
Carex inopinata	Kowhai Point Scenic Reserve, Marlborough	*Pinus* sp., broom, gorse, blackberry and others
Gunnera hamiltonii	Mason Bay, Stewart Island	macrocarpa, marram grass, tree lupin
Cromwell chafer beetle (*Prodontria lewisi*)	Cromwell Chafer Beetle Reserve, Otago	radiata pine, thyme, sweet brier, herbaceous weeds
Chafer beetle (*Prodontria* sp.)	Aldinga Conservation Area, Otago; Flat Top Hill Conservation Area, Otago	radiata pine, sweet brier, broom, thyme, and others; contorta pine, radiata pine, sweet brier, broom, gorse, and others
Un-named species of skink	Dunes at Big Bay and Martins Bay, Southland	radiata pine, macrocarpa, blue gum, tree lupin, broom
Southern rata (*Metrosideros umbellata*) forest and *Celmisia monroi* at southern limit	Mt Ararat Rata Reserve, Canterbury	radiata pine, nassella tussock (potential threat)
Tussockland and rockland communities on ultramafic rock	Red Hills (Richmond Range), Marlborough	contorta pine, radiata pine, Douglas fir, mountain pine, Corsican pine
Shrubland on ultramafic rock	Hackett (Richmond Range), Nelson	radiata pine?, contorta pine?
Bog pine (*Halocarpus bidwillii*) shrubland	Bendhu Scientific Reserve, Canterbury; Wilderness Scientific Reserve, Southland	contorta pine, elder, sweet brier, broom; radiata pine, Douglas fir, rowan, gorse, broom, heather
Tussockland, herbfield	Kirkliston Range, Canterbury	contorta pine, elder, sweet brier, broom
Tussockland and shrubland	Queenstown Hill, Otago	*Pinus* sp., sweet brier, broom

The EOS scores

In an attempt to determine the effect of invasive weeds on indigenous ecosystems for the purposes of ranking weed control priorities, weed species have been given an 'Effect on Ecosystems' (EOS) score in the Department of Conservation's database of ecological weeds on conservation land[10]. The EOS rating is an assessment of the characteristics of the weed species in the community type and geographic location where it has the greatest ecological impact. The criteria for establishing EOS scores are the ability of the species to significantly change the composition and structure of the habitat, the ability of the weed to suppress community regeneration, and the plant's persistence over time.

The four wilding conifer species or groups included in the database have been given scores between 8 (high) and 7 (low). All pines (*Pinus* spp) score 8, and Douglas fir scores 7. By comparison, old man's beard scores 9, gorse scores 7, and elder scores 6[10].

The EOS scores for wilding conifer species in the South Island were reassessed during the preparation of this strategy (See Page 42). Eight species were given an EOS score of nine (larch, contorta pine, big cone pine, mountain pine, Corsican pine, maritime pine, Scots pine, Douglas fir), and nine species were given a score of eight (Lawson's cypress, macrocarpa, Norway spruce, Sitka spruce, bishop pine, Ponderosa pine, radiata pine, redwood, western red cedar).

3.2 THE EFFECT OF WILDING CONIFER SPREAD ON OTHER VALUES

Effects on landscape values

Wilding conifers are one of the most prominent invasive weeds in the New Zealand landscape. Their upright conical growth form, the density and texture of their foliage, and the deep green colour of many conifers, provide a dramatic contrast to most native forest species. This contrast is even more obvious in grassland or shrubland communities, especially the extensive tussock grasslands of the South Island high country, where introduced conifers stand like sentinels in an otherwise open and expansive landscape. Spread from these outlier trees can soon obscure the contour and form of the land and alter the colour and texture of the landscape.

Wilding tree spread, and unregulated tree planting, is considered one of the most serious threats to tussock grasslands[30]. A survey of people with a wide range of perspectives on the high country in 1994 revealed widespread concern about wilding tree spread, with 75% of respondents considering it undesirable[31]. Wilding tree spread is not only obvious in open landscapes; it can also obstruct views, creating a Northern Hemisphere feel and hiding distant scenery.

The prominence of wilding conifers is such that their effects on landscape values are not confined to the open landscapes of the high country. Tall radiata pine trees, emerging from regenerating scrub and forest, are dominant in the Marlborough Sounds. Pine trees also dominate native scrub on broad fluvioglacial outwash terraces near Paparoa National Park on the West Coast. And, at coastal sites throughout the country, wilding conifers are prominent on dunes and coastal cliffs.

Effects on recreation

A direct effect of wilding conifer spread on recreation is obstruction of foot or vehicle access. Growth rates and tree densities of wilding spread at some sites are such that access along walking or vehicle tracks may be restricted. Good examples of this are at Queenstown on the popular walking tracks on Ben Lomond and Queenstown Hill, and at Hanmer on walking tracks near Hanmer forest.

Pollen produced by introduced conifers may be an irritant, especially to people prone to hay fever. Areas of wilding conifer spread may produce sufficient quantities of pollen at times to affect susceptible people and discourage recreational use.

However, probably the most important effect on recreation is the ability of wilding conifer spread to cause widespread change to the character of recreation sites. An important motivation for recreational use of a site is the anticipated appreciation of the vegetation, wildlife, and scenery at the site. While plantings of introduced conifers have their own appeal, and have created some popular recreation sites, the uncontrolled spread of introduced conifers onto grassland and shrubland communities will frequently detract from a visitor's recreational experience at the site. Interesting native plant communities and wildlife may be displaced and popular views obscured.

Effects on historic and cultural values

The uncontrolled spread of wilding conifers can also affect historic sites and cultural values. Tree roots may alter and damage historic building foundations and earthworks of Maori pa or early mining activities. Wilding trees may also damage urupa and early European graves. Wilding spread can totally obscure historic sites such as pa terraces, sites of early cultivation, water-races, gold diggings and tailings, and house sites. Good examples of the effect of wilding spread on early gold workings and settlements can be seen in several parts of Otago, at Naseby, Bannockburn and Skippers.

Early plantings of introduced conifers have, at some sites, considerable historic and cultural significance. Trees planted at Hanmer, Lake Coleridge, Mt Cook, Queenstown, and at other sites in the South Island, are tangible examples of the efforts of European settlers to establish and trial Northern Hemisphere conifers. Some of these plantings now provide a valuable resource for the study of the suitability of introduced plantation species. Introduced conifers at many other sites throughout the South Island mark the sites of the first residences of European settlers, such as macrocarpa trees at coastal sites (e.g. Stewart Island and on the Otago coast), and pine and larch trees at high country sites. However, the uncontrolled spread from these trees rarely has cultural or historic significance.

Effects on economic values

The main economic effects of wilding conifer spread are the reduced commercial potential of land and the costs of wilding control. A third category of economic effect is the 'welfare loss' caused by the presence of wilding conifers[32]. This latter effect is more difficult to quantify, though is similar to the effects discussed in the paragraphs above.

Reduced commercial potential of land due to wilding conifers is most likely to occur through the loss of grazing land presently used for extensive pastoralism. Wildings shade and eventually overwhelm grasslands, displacing favoured pasture species and reducing available forage. Farm and stock management may also be affected by even only scattered wilding spread by hindering mustering and restricting the extent of arable land.

Dense wilding spread may reduce water yields from montane slopes, especially in parts of the high country such as Central Otago. Any such reduction could have a critical effect on intensive land uses that depend on irrigation, such as viticulture. The availability of stock water may also be affected, an effect that may be critical during drought conditions. These effects may be exacerbated by climate change, including a possible reduction in the extent of snowfields.

It is difficult to quantify the likely commercial cost of wilding spread in the South Island. A cost benefit analysis of proposed wilding conifer control over an area of 29,868 hectares of extensive grazing land in the high country found that the net present value of benefits minus costs for the project was $48,696[33] or $1.60 per hectare. Costs, and therefore the net benefit of control, would be greater for more productive areas if such areas were similarly affected by wilding conifer spread. The cost of a reduction in irrigation water for more intensive land uses is likely to be even greater. However, most areas of DOC-administered land are not grazed or intensively farmed, so commercial losses on these lands as a result of wilding conifer spread are likely to be relatively minor.

An important, though less easily quantified, commercial cost of wilding spread on public conservation land is the potential reduction in revenues from tourism. Distinctive South Island landscapes, including the expansive tussock grasslands of the high country, are used extensively in tourist promotions. The loss of this landscape character, and the obstruction of important vistas, as a result of wilding spread (e.g. Lindis Pass Scenic Reserve viewed from State Highway 8) may limit the potential economic benefits of tourism. Other effects of wilding spread on tourism are similar to those identified above for recreation.

The costs associated with wilding conifer control on DOC-administered land are substantial. They comprise a significant proportion of the Department's plant pest control expenditure. Wilding conifer control is also a major focus of voluntary groups. These costs are discussed further in Section 5.4.

Wilding conifers may also have economic benefits by providing shelter and shade, reducing soil erosion, and as a source of timber. However, the instances where wilding conifers are more beneficial than purposely planted trees are rare; these benefits are more effectively provided by planned tree planting.

4. The Department's Control Obligations

4.1 STATUTORY OBLIGATIONS FOR WILDING CONIFER CONTROL

The Department of Conservation is required by legislation to control introduced plants on the land it administers under the Reserves Act 1977, National Parks Act 1980, and Conservation Act 1987. The Department also has obligations under the Biosecurity Act 1993. The requirements of these statutes are summarised below.

The primary responsibilities of the Department of Conservation are to control weeds that threaten indigenous ecosystems, historic resources, and recreation opportunities, on land that it administers; and to control regional pest plants (under the Biosecurity Act 1993) on or adjacent to land it administers.

Reserves Act 1977

This Act requires the Department to, among other things, *preserve* areas possessing *indigenous flora and fauna*, or areas of *environmental and landscape amenity or interest* that are protected as reserves under the Act. The Act specifically requires the Department to ensure that the *exotic flora and fauna shall as far as possible be exterminated* from scenic reserves (s.19(2)(a)), nature reserves (s.20(2)(b)), and scientific reserves (s.21(2)(a)).

National Parks Act 1980

This Act requires the Department to protect national parks as far as possible in their natural state and requires the Department to administer national parks so that the *introduced plants and animals shall as far as possible be exterminated* (s.4(2)(b)).

The National Parks Act requires the preparation of management plans for each of the eight national parks in the South Island. These plans contain policies and objectives for weed control, including wilding conifer control. National park management plans must be consistent with Conservation Management Strategies, which are discussed below.

Conservation Act 1987

This Act requires the Department *to manage for conservation purposes, all land, and all other natural and historic resources*, held under this Act (s.6(a)). '*Conservation*' is defined as *the preservation and protection of natural and historic resources for the purpose of maintaining their intrinsic values* (s.2(1)). '*Preservation*', in relation to a resource, is defined as *the maintenance, so far as is practicable, of its intrinsic values* (s.2(1)). '*Protection*', in relation to a resource, is defined as *the maintenance, as far as is practicable, in its current state*, and includes *its restoration to some former state* (s.2(1)).

The Conservation Act requires the preparation of Conservation Management Strategies (CMS). A strategy has been prepared for each of the five Conservancies in the South Island. All CMS documents require the Department to control plant pests to protect native species and communities, and historic resources, as required by

the legislation. All except the West Coast CMS require the Department to control plant pests to protect landscape values.

Conservation Management Strategies

Some of the Conservation Management Strategies contain specific objectives and policies for wilding conifer control. These are summarised below.

- Nelson/Marlborough Conservancy

The Nelson/Marlborough CMS contains no objectives or policies that are specific to wilding conifer control, though six introduced conifer species are listed as plant pests. 'Wilding tree' control is identified as a high or moderate conservation management priority at several sites in the Conservancy.

- West Coast Conservancy

The West Coast CMS contains no objectives or policies that are specific to wilding conifer control.

- Canterbury Conservancy

The Canterbury CMS plant pest objectives contain several specific references to 'exotic trees', including the requirement to:

- Remove or contain exotic trees in parks, reserves and conservation areas
- Prepare logging plans for harvesting of exotic trees
- Prepare operational plans for the control of exotic tree spread
- Advocate that district and regional plans provide for the control of 'wilding pine' spread
- Prepare an inventory of exotic trees on DOC-administered land.

- Otago Conservancy

The Otago CMS objectives contain several specific references to wilding conifers, in both the objectives for different parts of the Conservancy and the objectives for plant pest control. Implementation statements include the requirement to advocate that owners of conifers producing wildings be responsible for the control of that wilding spread. The CMS also identifies the eradication of isolated wilding conifers, and the containment of larger infestations, as a priority for plant pest control.

- Southland Conservancy

The Mainland Southland/West Otago CMS contains no specific objectives for wilding pine control. However, implementation of the objectives requires the control of contorta pine and other wilding pine spread where practical.

All Conservation Management Strategies refer to Area, Conservancy, or national plant pest strategies to guide plant pest control. Information on wilding conifer infestations has been extracted from these plant pest strategies and incorporated into the schedule that forms Appendix One of this Wilding Conifer Strategy.

Note that the Strategic Plan for Managing Invasive Weeds (SPMIW), which has been used to determine the control priorities listed in the Schedule to this Wilding Control Strategy (Appendix 1), ranks plant pest control according to the botanical and wildlife values of the site. The SPMIW does not consider historic values, landscape values, or the loss of recreation opportunities in setting control priorities. The Department has other strategies and processes for assessing control priorities to protect these values.

Biosecurity Act 1993

This Act repeals the Noxious Plants Act 1978. The administration of this Act is largely the responsibility of Regional Councils (sections 13, 14 and 15, Biosecurity Act 1993). The Act enables the preparation of national or regional pest plant

management strategies to help ensure that pest plants are adequately controlled. DOC is bound by national strategies, whereas regional strategies are only binding with the agreement of the Minister of Conservation (Biosecurity Act 1993, sections 5 and 87).

Regional Plant Pest (or Pest Plant) Strategies (RPMS) have been prepared by Regional Councils or Unitary Authorities for all parts of the South Island except the West Coast. However, none of the strategies include wilding conifer species as total control or boundary control pest plants. Contorta pine is listed as a surveillance plant in the Canterbury, Otago, and Southland RPMS documents. This listing prohibits the sale, distribution, or propagation of contorta pine in those three regions.

The Southland Regional Council is considering the inclusion of contorta pine as a total control pest plant in the Southland Regional Pest Plants Management Strategy.

Environment Canterbury (formerly the Canterbury Regional Council) has released a 'New Pests Discussion Document' (1999) that proposes options for wilding conifer control in the Canterbury Region. Six species are included (mountain pine, contorta pine, Corsican pine, Scots pine, larch, Douglas fir), and three options are proposed:

- Control through education, advice, and encouragement;
- Eradication within 10 years; and,
- Eradication of specified trees in specified areas.

Public response to the discussion document will assist Environment Canterbury to determine whether to include wilding conifers in any review of the RPMS (Ray Maw, EC, *pers.comm.,* April 2000).

4.2 OTHER OBLIGATIONS FOR WILDING CONIFER CONTROL

As well as the statutory responsibilities outlined above, the Department has general obligations as a land management agency. Land tenure boundaries present no obstacle to wilding conifer spread. Wilding spread can have significant impacts on productive land uses, such as farming and forestry, which frequently occur on lands adjoining those administered by the Department.

To maintain and develop good relations with adjoining landholders, there may be circumstances where the Department may attempt to control wilding conifer spread that poses a threat to neighbouring properties. It is beyond the scope of this strategy to determine when such control efforts are justified, and how such control is ranked alongside the Department's statutory obligations for wilding conifer control.

It should be noted that the reverse effect, where wilding conifer spread on adjoining land threatens DOC-administered land, is more common.

5. A strategy for wilding conifer control

Wilding conifers pose a significant threat to indigenous ecosystems, populations of rare species, landscape character, historic and cultural values, recreation opportunities and commercial land uses throughout the South Island. Wilding conifer spread is widespread, variable in its effects on conservation values, and indiscriminate in the tenure of land that it affects.

The Department of Conservation is unlikely to ever have sufficient resources to control all wilding conifer infestations. For this reason, a strategy is required to ensure that wilding conifer control is carefully targeted to yield maximum conservation benefit. However, a strategy must address more than just wilding conifer control. ***Advocacy*** to convince others of the need for wilding conifer control, ***liaison*** with other land managers to coordinate control efforts, and ***research*** to improve threat assessment and control actions, are all required to help ensure that wilding control is effective and sustainable.

These four components of the Wilding Conifer Control Strategy are discussed in the sections below.

5.1 ADVOCACY

Advocacy is one of the most important parts of wilding conifer control. Without effective advocacy the Department is likely to struggle to attract sufficient funding for control programmes, will have its control programme undermined by the presence of aggressive introduced conifers at inappropriate sites, and will need to continue to counter the view that all trees are good. Conservation advocacy is needed to publicise the wilding conifer problem, and to win support for control programmes.

During the preparation of this strategy, the following conservation advocacy targets were identified:

- District Councils to ensure District Plans avoid, remedy or mitigate the effects of introduced conifer plantings, especially to ensure that effects such as seed dispersal are included in the consideration of land use consents
- Regional Councils (and Unitary Authorities), for the inclusion of appropriate species of wilding conifer in Regional Plant Pest Management Strategies
- Regional Councils (and Unitary Authorities), to take a more active role in coordinating wilding conifer control across all land tenures
- Government, for increased funds for the control of wilding conifer spread, and for funds to be assured for the term of the control programme
- Land managers, especially in the eastern South Island high country, to raise awareness about the threat posed by wilding conifers and the extent of this threat
- Plantation managers, to manage plantations in a way that minimises the risk of spread (e.g. provision of buffers, avoiding take-off sites)
- The community generally, to raise awareness about the threat posed by wilding conifers and the extent of this threat

Also identified during the preparation of this strategy were the following information needs, to enable effective conservation advocacy:

- Mapping existing areas of spread (using GIS), to more effectively illustrate the extent of wilding conifer infestations (though any maps of wilding spread would require regular updating)
- Modeling wilding conifer spread scenarios (perhaps using computer-generated images), to help convince people of the potential threat posed by wilding conifers
- Maintaining the national electronic database on invasive weeds, to ensure that information on wilding conifer infestations is up to date and readily accessible.

The inclusion of aggressive wilding conifer species in Regional Pest Plant Management Strategies and the inclusion of conditions on resource consents for the establishment of plantations are important advocacy goals. Achievement of these goals would help ensure that all landowners accept responsibility for wilding spread. It would also help ensure that DOC's control of wilding conifers is sustainable. Conversely, failure to achieve this goal would mean that DOC's control efforts continue to be compromised by the presence of wilding conifers on adjoining land.

Case Study

Environment Canterbury Volunteer Wilding Conifer Control Days

Since 1993 Environment Canterbury (previously known as the Canterbury Regional Council) has organised and supervised wilding conifer control days in the Canterbury high country. Normally two control days are organised each year at accessible sites where wilding conifer spread is affecting important natural values, including landscape character. Sites are inspected prior to control and a commitment sought from the landowner to remove seed trees and continue to control wilding conifers at the site. Control days are publicised through the news media and directly to clubs and groups. Funding for the volunteer control days comes from Environment Canterbury's advocacy budget.

Each volunteer control day now attracts over 100 people, including members of tramping clubs, conservation groups and individuals from the local community. Local Landcare groups and landowners have also supported control days by assisting with the control effort and providing transport. Control days often end with a barbecue and, on some occasions, local accommodation is provided. Organisation of the volunteer control days is a substantial exercise occupying two Environment Canterbury staff for about a week, and sometimes including support from the New Zealand Army for transport.

Wilding conifers have been removed from over 24,000 hectares, including high profile sites such as Burke Pass, Lake Pukaki, Lake Coleridge, Porters Pass and Lake Lyndon. Approximately 3,000 hours of volunteer effort have been expended in thirteen separate control days. The control days have helped raise public awareness about the impact of wilding conifers on the natural character of the Canterbury high country. They have also helped encourage the development of a partnership approach to the wilding conifer problem. Environment Canterbury plans to continue organising volunteer wilding conifer control days as part of its advocacy and plant pest control objectives.

***Note:** Quality control is an important requirement for successful volunteer wilding conifer control. Control day participants are reminded that if green foliage is left on the stump after cutting, the tree will continue to grow and will be more difficult to remove the second time.*

5.2 LIAISON

The Department of Conservation is only one of many land managers that are faced with the threat of wilding conifer spread. Coordination of control efforts, and associated activities such as research and information gathering, is an essential part of wilding conifer control.

During the preparation of this strategy, the following liaison requirements for wilding conifer control were identified:

- Between Regional Councils, to coordinate approaches to wilding conifer control under the Biosecurity Act 1993
- Between managers of adjoining properties, to ensure that control efforts are coordinated
- Between DOC and forestry companies to identify the most effective herbicides and techniques for wilding conifer control
- Between community groups and land management agencies, to coordinate wilding conifer control, and to share information about control methods

Case Study
Forest and Bird's Wilding Tree Control Group
and the proposed Accord on Wilding Tree Control

Forest and Bird's Wilding Tree Control Group, and its proposed Accord on Wilding Tree Control, had its origins in a workshop organised by Professor Alan Mark (Forest&Bird and Otago Conservation Board) and chaired by Katharine Dickinson (Otago University and NZ Conservation Authority) in Dunedin in 1997. The workshop was prompted by increasing concern at the spread of wilding trees (conifers and other trees) in Otago and Southland, and the impacts of this spread on tussock grasslands and other values including landscape character.

People representing a wide range of interests participated in the workshop and agreed to develop an Accord that would encourage the containment and (where feasible) the eradication of wilding trees. Eighteen agencies and organisations have now given their formal support, and a further eleven groups have given informal support, to the Accord.

At the same time, Forest and Bird's Dunedin Branch sought and gained funding from the Lottery Grants Board and other sources to "facilitate the containment and, where possible, the eradication of wilding trees in areas of conservation value in Otago, through both practical and political efforts". The first actions were the purchase of three chainsaws, protective clothing, and a tuition course. Now the group has a pool of over 60 volunteers, and the activities of the group are organised by a paid part-time coordinator[34].

By April 2000, Forest and Bird's Wilding Tree Control Group had removed over 44,000 wilding trees from eleven separate sites throughout Otago. The total expenditure of the group during this time was just over $33,000 (D.McFarlane, pers.comm.). Nineteen sites have been identified as priority sites for wilding tree removal. Before wilding control work is undertaken a commitment is sought from the landowner to ensure that monitoring and control will be undertaken to minimise the risk of wildings becoming re-established at the site.

A further meeting of over 120 people in March 1999 in Cromwell established the Otago Southland Wilding Tree Management Committee.

Note: the group removes all wilding trees (conifers and other species)

5.3 RESEARCH

Historically, most introduced conifer research projects in the South Island have investigated the suitability of introduced conifers for timber production, soil conservation, and amenity planting. The effects of plantation forestry, notably the effects on catchment water yield, have also been researched. Until relatively recently, there has been little specific research that has investigated wilding conifer spread and the control of such spread.

As wilding conifer spread has become more common (and frequently arisen from trial plantings) the research focus has broadened to investigate the incidence and characteristics of wilding spread. However, the techniques for controlling wilding conifer spread have largely been developed through experience, rather than research. Little research funding has been allocated to the development of control methods or to the assessment of the threats posed by wilding conifers. To what extent this lack of funding may have limited the effectiveness of wilding conifer control is unclear.

Further research has the potential to help ensure that wilding conifer control efforts are more effective. Research may also help set priorities for wilding control that will provide better protection for conservation values. Several possible research topics were identified during the preparation of this strategy. These are listed and discussed below.

Physical Control

Physical removal of wilding conifers by hand or with machinery is the most common form of control. This usually involves removing all green foliage from the tree. However, it is not clear how important it is to remove every bit of foliage, or every epicormic shoot, from the tree. Research trials to determine the extent to which foliage must be removed to kill the tree, for each wilding conifer species and at different seasons, would be useful.

Chemical control

The control of dense infestations of wilding conifers by herbicides has been attempted at many locations. For example aerial application trials using different chemical mixes at a range of concentrations were undertaken on Mount Bee, Southland, in 1996 with mixed results[35]. Chemical control trials have also been undertaken in the central North Island, and by the Forest Research Institute at Rangiora[36]. The success of chemical control is dependent on identifying the optimum herbicide concentration and mix, and application method, which will effectively kill wilding conifers without affecting non-target species.

It appears that the response of wilding conifers to herbicides may vary considerably between species and sites. It is likely that the optimum herbicide application at one site may not achieve the same results at another site, as there is considerable variation in the vigour of wilding conifer species at different altitudes and climates. However, some wilding conifer infestations are so extensive that research by management, where rates of herbicide application are refined through control trials, appears worthwhile. The easiest way to decide upon herbicide application rates may be to seek advice from experienced weed control operators who are familiar with wilding conifer control (Nick Ledgard, FRI, *pers.comm*). Some DOC employees also have considerable experience with chemical control.

A possible area for research is the assessment of effects of herbicide application rates on non-target species. The Department must be reassured that the application of herbicides for wilding conifer control does not result in the loss of the biodiversity values that such control is attempting to protect. Furthermore, the

successful rehabilitation of infestation sites after control programmes may depend on the survival and vigour of healthy ground-cover or inter-conifer vegetation.

Biological control

The possibility of isolating and introducing a biological control agent for wilding conifers has been discussed for some time. Preliminary work has been undertaken investigating invertebrates that eat the seed of contorta pine[37].

Research to isolate and test possible biological control agents is likely to be time-consuming and expensive. There are also several possible obstacles to the introduction of a biological control agent for wilding conifers. Nurseries and forestry companies producing seeds or seedlings for conifer plantings are likely to be opposed, unless the conifer species can be easily and successfully cloned. The susceptibility of native conifers – especially species in the Araucariaceae (kauri) and Cupressaceae (cedar) families – would need to be investigated. It is also possible that a seed-eating biological control agent may not be effective in reducing wilding conifer spread.

However, the introduction of a successful biological control agent for an aggressive wilding species such as contorta pine could dramatically reduce the costs, and increase the effectiveness, of wilding conifer control at some sites. It could also assist commercial forestry proposals seeking consent under the Resource Management Act 1991 if it could be shown that seed will not be dispersed from plantations. Biological control agents for contorta pine may also affect other introduced conifers such as Ponderosa pine and Corsican pine[37]. Biological control appears a worthy area for further research.

Restoration/rehabilitation

One of the most important management issues associated with wilding conifer control is the restoration or rehabilitation of infestation sites once wilding conifers have been removed. This is particularly important at sites where dense or closed-canopy wildings have been removed, at sites prone to soil erosion, and at sites where re-infestation by wilding conifers or other weed species is likely. Some of the most extensive wilding conifer infestations on DOC-administered land are erosion-prone sites.

Traditionally, the rehabilitation of erosion-prone sites has been attempted through the use of introduced herbaceous species, such as lotus (*Lotus pedunculatus*) or browntop (*Agrostis capillaris*), or woody species such as alder (*Alnus* spp.) or introduced conifers. The use of these species is not appropriate on DOC-administered land, especially where vulnerable indigenous biodiversity values are threatened.

Native species will often successfully colonise new sites, but may not be resilient to competition from introduced species. One option is to sow seed of native shrub species, possibly with fertiliser, to encourage the establishment of native woody species that are relatively resilient to invasion by introduced herbaceous plants. Research into suitable species, techniques and appropriate sowing (and possibly fertilising) rates would be useful.

Another option is to inter-plant wilding conifer infestations with native tree species, then remove the conifers once the native trees are well established. Research into this technique may also be worthwhile. However, both these areas of research are likely to be costly.

Douglas fir spread into native forest and shrubland

Douglas fir is the only wilding conifer species in the South Island that is sufficiently shade tolerant to colonise native forest communities. The colonisation of native mountain beech forest by Douglas fir has been studied near Arthur's Pass[14] but the succession of Douglas fir within native forest, and the susceptibility of other native forest or shrubland communities, has not been investigated.

Research into the susceptibility of native forest and shrubland to Douglas fir invasion, and the extent to which Douglas fir is likely to dominate these plant communities, would assist in the assessment of control priorities. Such research could include a survey of areas of native forest or shrubland adjacent to mature Douglas fir trees.

Succession in wilding conifer infestations

Many wilding conifer infestations are in shrubland communities, where scattered trees out-compete the regenerating native shrub or tree species. The role of introduced conifers in such communities, including the likelihood of further wilding conifers becoming established in light gaps, the effect of scattered mature wilding conifers on the susceptibility of the community to fire, and the effect on species habitat, are possible research topics.

Research into the successional role of wilding conifers in native shrubland and forest would assist with the assessment of threats, and control priorities, in many coastal areas (such as the Marlborough Sounds), and on montane sites that formerly supported forest (such as in large parts of the eastern high country).

Threat assessment

Assessments of the threat of wilding conifer spread are usually based on four main factors: the spreading vigour of the species; the palatability of the species; the siting of the seed trees; and, downwind land management[13]. However, the spreading vigour of wilding conifer species varies considerably depending on site characteristics (such as the plant communities threatened), altitude, and climate (especially rainfall and temperature). Furthermore, for infestations on DOC-administered land, the downwind land management is usually similar (i.e. no grazing).

Research that refined the assessment of threat posed by wilding conifers, by adding other variables to the threat assessment process, would be very useful for determining control priorities. Other threat factors, such as seed dispersal distances, the effects of buffering plantation margins on seed dispersal, the upper altitude at which wilding conifers will establish, and the role of substrate in seedling establishment would also be useful areas for further research.

Social Research

Investigation of people's perceptions of wilding conifer spread, and of the effectiveness of the Department's advocacy efforts, may also be a useful area of research.

Modeling wilding conifer spread

Wilding conifer spread is to some extent predictable. Typical spread scenarios could be modeled to illustrate the area likely to be affected by wilding conifers, and the density of tree spread, over varying periods of time. The inherent difficulty with such modeling is the variability of spread between wilding conifer species and between sites. However, models of typical, or perhaps worst case, spread scenarios would be useful for conservation advocacy.

Case Study
Wilding Conifer Control compared with other Conservation Projects

The benefits of conservation projects, including wilding conifer control, are difficult to quantify. In an attempt to quantify these benefits, a modeling exercise was undertaken using actual and potential conservation projects in the Twizel area[38]. The exercise measured the efficacy, urgency, and feasibility of a range of conservation projects to determine the merit and cost effectiveness of each project. Two wilding conifer control scenarios were modeled: wilding conifer control on DOC-administered land; and, control on DOC land in addition to the inclusion of wilding conifers in the Regional Pest Management Strategy (RPMS) (requiring wilding conifers on other lands to be controlled by landowners).

The modeling exercise showed that the natural character of DOC-administered land would decline significantly if conservation management were limited to current and planned conservation projects, including wilding conifer control. However, if wilding conifers are included in the RPMS, natural character will be maintained because fragmentation of surrounding lands by conifer infestations will be prevented.

The modeling exercise concluded that the inclusion of wilding conifers in the RPMS combined with control on DOC-administered land, was the project with the most merit of the 25 conservation projects considered. Next, in terms of merit, was the control of wilding conifers on DOC-administered land (without the inclusion of conifers in the RPMS). When measured for cost-effectiveness, the inclusion of wilding conifers in the RPMS combined with control on DOC-administered land was the second-most cost-effective project after another weed control project (yellow lupin eradication).

While this modeling exercise provides an indication of the relative merit and cost-effectiveness of wilding conifer control projects, notably the inclusion of wilding conifers in the RPMS, the conclusions of the exercise should be interpreted with caution. The relative merit and cost effectiveness of each conservation project can be influenced by the objectives selected for the project, and the assessment of the feasibility (and risk) of each project. To seek the inclusion of wilding conifers in a RPMS for an area where there are substantial existing infestations may be unachievable due to landowner and agency opposition.

Note:

Research proposals would be assessed against priorities in the Department's Weed Research Plan.

5.4 CONTROL

Prevention

Ideally, wilding conifer spread should be prevented, so that control is not required. Actions to prevent tree spread include[18]:

- Removal of existing or potential seed sources
- Avoiding the planting of spread-prone species
- Designing and siting plantings to minimise the risk of spread
- Intensive use, such as cultivation or mob-stocking, of surrounding land
- Regular checks of downwind sites, and removal of any wilding seedlings

These preventative measures may be possible on DOC-administered land though not all, such as mob-stocking, are desirable. However, for lands not administered by DOC the most important action is advocacy to both increase awareness of the threat posed by wilding conifer spread and to seek the inclusion of aggressive wilding conifer species in Regional Pest Plant Management Strategies. If that cannot be achieved, liaison with land managers and coordinated containment of infestations may help reduce the threat of wilding conifer spread onto DOC-administered land.

Control actions

In situations where wilding conifer spread has already occurred, such as at the infestation sites included in this strategy, control of wilding conifers is required. The most important ingredient of a successful control operation is good planning. Poorly planned control operations can waste valuable resources, risk staff and equipment, and sometimes make future control operations at the site more difficult.

The most important control action will usually be to remove outlying trees before they cone, particularly trees located at exposed ('take-off') sites. Such action will help contain the wilding conifer infestation and reduce the risk of a rapid increase in the extent of the infestation. The removal of outlying trees is probably the most cost-effective early control action at most infestation sites. Inspection of areas surrounding the infestation site, to locate and remove outlying wilding trees, should be undertaken every three to five years, so that wilding seedlings are detected and removed before they cone.

Complete removal (eradication) of a wilding conifer infestation may be contemplated once the early containment of the infestation (by the removal of outlying trees) has been undertaken. To effectively eradicate an infestation, all seed trees must be removed, control must be sustained for several years until dispersed seed is no longer viable, and the risk of re-infestation from seed sources beyond the infestation site must be negligible.

Eradication of wilding conifer infestations is obviously the most desirable goal. The wide distribution of introduced conifers, and the distances over which conifer seed can be dispersed, will preclude the sustained eradication of wilding conifers at many sites in the South Island. However, the cost of maintaining a site clear of wilding conifers during the early stages of an infestation (before trees cone) is relatively low. Seedlings can be pulled by hand, and substantial areas covered by foot (or checked from the air), for as little as $2 per hectare[12].

Control Methods

The most appropriate method for controlling wilding conifers will depend upon a range of factors, including the:

- Extent of the infestation
- Density of the trees
- Size and age of the trees
- Species of conifer present
- Access to and within the site
- Native vegetation and other biodiversity values within or surrounding the site
- Skills and resources available for control

Commonly used methods for wilding conifer control[18], include:

- Grazing (although intensive grazing at two-yearly intervals is usually required for effective control)
- Burning (although fire often creates ideal conditions for re-invasion of wilding conifers and other weeds)
- Hand-pulling of seedlings
- Felling with hand tools or power tools (with or without herbicide treatment of stumps)
- Ring-barking of larger trees
- Application of herbicide

Physical control, by hand-pulling of seedlings or felling of larger trees, is usually the most efficient and cost-effective form of control. The conservation values present on the lands administered by DOC will often preclude the use of intensive grazing or burning for wilding conifer control.

Best practice for wilding conifer control

Successful wilding conifer control is dependent on adopting good practices for all stages of the control operation. The 'best practice' actions for physical control are listed in the box on the following page. Standard Operating Procedures (SOPs) adopted by the Department should be used to guide these and other components of wilding conifer control. Relevant SOPs include:

- Monitoring Weed Control
- Surveillance
- Work Plan Specifications
- Strop Flying (draft SOP, East Coast/Hawke Bay Conservancy)

Also relevant is the Department's Invasive Weeds Database.

The cost of wilding conifer control

The cost of wilding conifer control varies considerably depending on the accessibility and ruggedness of the site, the density of the tree spread, the size of the tree, the control method, and the labour employed. It is often difficult to accurately determine these factors, and especially the extent of different densities of wilding conifer spread, at each infestation site. Therefore it is difficult to estimate likely control costs with great accuracy.

A recent assessment of wilding conifer control at Mid Dome, Southland[12], conservatively estimates the costs of removing wilding conifers at different infestation densities as follows:

Type of control	Cost per hectare	Comment
contract clear-felling of plantations or dense stands of trees	$1,000 to $1,500	based on control operations at Mt Bee (1998/99) and Molesworth, and at a rate of $28/hour (48 hours/ha)
contract removal of dense fringe spread (>2,000 stems/ha) with chain-saws and hand tools	$560 to $840	based on control operations in 1980s, and at a rate of $28/hour (20-30 hours/ha)
contract removal of frequent outliers (500-2,000 stems/ha) with chainsaws and hand tools	$300	based on control operations in 1980s, and at a rate of $28/hour (10 hours/ha)
contract removal of regular outliers (100 to 500 stems/ha) with chainsaws and hand tools	$150	based on control operations at Mt Bee (1998/99), and at a rate of $28/ha (5 hours/ha)
contract removal of lightly scattered wildings (1 to 100 stems/ha) with chainsaws and hand tools	$55	based on control operations at Mt Bee (1998/99), and at a rate of $28/ha (2 hours/ha)
contract removal of widely scattered lone outliers (<1 stem/ha) with chainsaws and hand tools	$2	based on control operations at Molesworth 1998 (includes the cost of Robinson helicopter, pilot and chainsaw operator)

The costs listed above do not include the cost of follow-up inspections and the removal of new seedlings. Such follow-up control is essential to protect the investment in the initial control operation.

An assessment of the cost of removing wilding conifers in the Mackenzie Basin[15] produced similar figures to those quoted above:

Tree density (trees/ha)	Removal Cost ($/ha)
<10	<10
10-100	10-100
100-1000	100-300
1000-5000	300-1700

Setting priorities for wilding conifer control

Weed control operations undertaken by the Department of Conservation are guided by the Department's Strategic Plan for Managing Invasive Weeds (SPMIW)[39]. This plan separates weed control programmes into 'site-led' and 'weed-led' programmes. No wilding conifer species are presently covered by 'weed-led' programmes in the South Island. All known site-led wilding conifer control programmes in the South Island are listed in the schedule in Appendix 1 of this Wilding Conifer Strategy.

The relative priority of each site-led programme is determined, under the SPMIW, by the 'total score' attributed to each site. The total score is derived from the higher of the 'botanical' or 'wildlife' scores of the site multiplied by an 'urgency' score. The botanical, wildlife, and urgency scores are allocated according to sets of criteria listed in Appendix 5 of the SPMIW.

The priority-setting process set out in the SPMIW is based on the biodiversity value (botanical or wildlife value) of the site. It does not consider the value of landscape character, historic or cultural resources, or recreation opportunities at the site as part of the priority-setting process. The Department has separate strategies for ranking threats to these values.

Wilding conifer infestations that threaten DOC-administered land in the South Island are listed in Appendix 1 in order of the priority for control (from highest to lowest priority) as determined by the process outlined in the SPMIW, as follows:

1. Infestation sites have been sorted in order of priority for control based on the total score (biodiversity x urgency) of each site, from 21 (highest priority) to 1.5 (lowest priority);
2. Infestation sites with the same total score have then been sorted so that the sites where wilding conifers do not threaten biodiversity values (i.e. where wilding conifers have a lower urgency of control score than other invasive weeds) are placed lower in the list of priorities (these sites are marked by an asterisk in the 'total score' column);
3. Then, infestation sites with the same total score are sorted further depending on the risk of re-infestation. This risk is ranked 'low', 'low-medium', 'medium', 'medium-high', or 'high', and noted in the 'total score' column of the schedule. Sites with a low risk of re-infestation are ranked as a higher priority for control than sites with a high risk of re-infestation;
4. Then, infestation sites with the same total score and the same re-infestation risk are sorted in order of size. Small sites are ranked as a higher priority for control than large sites.

(only sites scoring 12.5 or more are further sorted at stages 3 and 4)

Several other factors were considered for ranking wilding conifer control priorities, but not used for the following reasons.

Weediness Scores: The weediness of each wilding conifer species varies considerably depending on location, altitude, climate, and site characteristics. Insufficient information was available about each infestation to accurately estimate the relative weediness of each wilding conifer species at the site. Similarly, the 'spreading vigour' of species at different sites was also considered too variable to enable easy and accurate assessments.

Practicality of Control: This assessment, set out as Figure A4.1 in the SPMIW, is designed for weed-led rather than site-led control programmes. It was considered inappropriate to attempt to adapt that assessment to rank site-led programmes. However, one of the main components of that assessment – the risk of re-infestation – has been used to rank sites (stage 3, previous page). Furthermore, the size of the infestation (used as the last criterion – stage 4, previous page) assesses another component of the practicality of control.

Landscape, recreation, or historic values: No widely-accepted sets of criteria for these values, or comprehensive assessments of these values at each infestation site, were available during the preparation of this strategy. So, while it was tempting to use the presence of landscape values (for example) as a criterion, any such assessment would have been based on limited information and been very subjective.

Presence of other weeds: This factor was not used, partly because information on the other weeds present was not available for some important sites. However, it may be the next most useful criterion to use.

6. Implementing the strategy

Successful implementation of this Wilding Conifer Strategy for the South Island requires achievement of the right balance between each of the four components of the strategy: advocacy, liaison, research and control. Work in each of these component areas has the potential to reduce the threat posed by wilding conifers to DOC-administered land in the South Island.

It is tempting to advocate that wilding conifer control must be the most important action taken by the Department to protect biodiversity values and other values on the land it administers. However, while control is important, there are advocacy, liaison and research actions that, if successful, may reduce the potential extent or cost of control, or may ensure that the control effort is more sustainable.

Priority actions in each of the four component areas are listed and discussed below. Not all possible actions are listed; only those that are considered essential or very desirable to ensure that the Department is able to meet its statutory obligation to protect the values of the land it administers from the spread of wilding conifers.

6.1 ADVOCACY

ACTION 1 PUBLIC AWARENESS

Publicize the extent and effects of wilding conifer spread, using examples from throughout the South Island, to create greater awareness of the threats posed by wilding conifer spread.

Explanation:
Despite the dramatic examples of wilding conifer spread in the South Island, there is still a widely held view that any trees in any location are good. Greater publicity about the extent of wilding conifer spread and the effects of such spread on ecological, landscape and economic values, is required to counter this view. The use of computer-generated images of likely spread scenarios may assist with such advocacy.

ACTION 2 BIOSECURITY ACT 1993 (RPPMS) AND RESOURCE MANAGEMENT ACT 1991 (RMA) ADVOCACY

Seek the inclusion of aggressive wilding conifer species as pest plants in Regional Pest Plant Management Strategies (RPPMS) in areas where they pose a significant threat to biodiversity values.

ACTION 2A PREVENTION

Seek the inclusion of aggressive wilding conifer species as surveillance pest plants in Regional Pest Plant Management Strategies in areas where they are not already present and where their presence would pose a significant threat to biodiversity values.

ACTION 2B CONTAINMENT

Seek the inclusion of aggressive wilding conifer species as containment control pest plants in Regional Pest Plant Management Strategies in areas where they are already present and where their presence poses a significant

threat to adjoining areas with high biodiversity values that are presently unaffected by wilding conifer spread.

ACTION 2C CONTROL

Seek the inclusion of aggressive wilding conifer species as total control pest plants in Regional Pest Plant Management Strategies in areas where their presence poses a significant threat to biodiversity values and where their removal is practical and affordable.

ACTION 2D MITIGATION

Seek the inclusion of conditions on resource consents for new plantings of aggressive introduced conifers, or the decline of consent for such proposals, to avoid, remedy or mitigate the effects of wilding conifer spread from new plantings.

Explanation:
The inclusion of wilding conifer species in Regional Pest Plant Management Strategies (RPPMS) would give the species the status of a plant pest under the Biosecurity Act 1993, and would impose a statutory obligation on landowners to take action as prescribed in the relevant RPPMS. Any such inclusion would help ensure that the Department's control efforts are sustainable. It would also help protect important conservation values threatened by wilding conifers on lands not administered by the Department.

The most obvious wilding conifer species for inclusion is contorta pine. This is one of the most aggressive and widespread species in the South Island high country. It is not generally planted for amenity purposes and has little present value as a timber tree. However, there may be considerable resistance to its inclusion from landowners in parts of the high country where contorta pine is widespread.

Corsican pine, Douglas fir, radiata pine and larch are the other most widespread species. However, Douglas fir, radiata pine and Corsican pine are important timber trees, and larch is commonly planted as an amenity tree. It may be most appropriate to list these wilding conifer species as containment control pest plants in certain high-value areas. Such listing would require landowners to contain existing infestations and to use alternative species for timber or amenity plantings. Alternatively, these wilding conifer species could be included as progressive control pest plants, requiring the phased removal of planted trees and wilding spread from defined areas over time.

Resource consents are usually required for new plantings of introduced conifers. The consent process under the Resource Management Act 1991 requires an assessment of the effects of the proposed planting, such as the effects of wilding conifer spread. Consent authorities can place conditions on consents to ensure that the effects of the activity are avoided, remedied or mitigated. Involvement in the consent process, where appropriate, would enable the Department to seek conditions that would help prevent wilding spread.

ACTION 3 COORDINATION

Promote coordination between agencies, groups and individuals in their response to wilding conifer threats.

Explanation:
Wilding conifer spread occurs regardless of land ownership and property boundaries. A wide range of agencies, landowners and individuals are affected by wilding conifer spread. A coordinated response to wilding conifer spread would help ensure that control efforts are more effective and more sustainable. The Department can play a key role in encouraging such coordination.

Continued coordination between the Department's Conservancies and Areas will also help ensure that the Department's advocacy is consistent.

ACTION 4 SURVEY AND INVENTORY

Seek assistance and cooperation from other agencies, groups and individuals for the survey, monitoring and recording of wilding conifer spread.

Explanation:
Information about the extent of wilding conifer spread in the South Island, and the species forming such spread, is inadequate at many sites. The collection of accurate data about the location and extent of spread, the species involved and the effects of control operations would enable agencies and individuals to make more accurate assessments of the extent of the threat and adequacy of control.

ACTION 5 INFORMATION PROVISION

Provide information to assist others in their efforts to prevent, contain or control wilding conifer spread.

Explanation:
The provision of good information about wilding conifer spread will help prevent future spread and help ensure the most effective response to existing spread. Information could be provided on the following:

- alternative tree species (i.e. non-spreading species)
- spread prevention techniques
- best practice for control operations
- descriptions and/or keys for wilding conifer species
- the benefits of early control efforts

6.2 LIAISON

ACTION 6 DEPARTMENTAL COORDINATOR / LEAD CONSERVANCY

Appoint a DOC staff member as a Departmental Coordinator and/or appoint a 'lead Conservancy' to coordinate and guide the Department's response to the wilding conifer threat.

Explanation:
The appointment of a Departmental Coordinator and/or a Lead Conservancy will help ensure coordination of effort within the Department and will provide a clear point of contact for non-DOC agencies, groups and individuals. It will also help ensure that advocacy about wilding conifer threats is clear and consistent.

ACTION 7 IWI INVOLVEMENT / INTEREST GROUP IDENTIFICATION

Confirm the method and protocol for iwi involvement. Identify interested agencies, groups and individuals.

Explanation:
Effective liaison must include clarification of the interests and role of iwi. Liaison must also be preceded by the identification of agencies, groups and individuals involved or interested in wilding conifer spread.

ACTION 8 GROUP LIAISON

Initiate, and participate in, a coordinated response to wilding conifer threats.

Explanation:
The Department is well placed to initiate and support liaison between groups and individuals affected by wilding conifer spread. Participation of the Department in such groups is likely to be mutually beneficial.

Examples of such liaison include the Mid Dome Wild Tree Management Committee (Southland) and the Pinus Contorta Coordinating Committee (central North Island).

ACTION 9 STEERING GROUP ESTABLISHMENT

Establish a South Island Wilding Conifer Steering Group.

Explanation:
The establishment of a South Island Wilding Conifer Steering Group would help ensure effective coordination between agencies, and would provide a forum for consideration of the wider political and institutional issues that influence the national or regional response to wilding conifer threats.

Such a group could include representatives from District and Regional Government, farming/landowner groups, forestry companies, DOC Conservancies, research organizations, and conservation and recreation groups.

6.3 RESEARCH

ACTION 10 SETTING RESEARCH PRIORITIES

Convene a meeting of key staff and research associates to prepare a list of the research projects that will most effectively assist the Department in its response to the threat posed by wilding conifers.

Explanation:
There are many areas of research that have some potential to assist the Department in its response to threats posed by wilding conifers. These are discussed in some detail in Section 5.3. The most important areas for further research at present appear to be the refinement of present control methods (especially physical and chemical control) and refinement of the threat assessment process. A number of separate investigations could contribute to research in these areas, some of which may only require the collation of existing information rather than undertaking further trials or experimentation.

Research proposals would be assessed against priorities in the Department's Weed Research Plan.

6.4 CONTROL

ACTION 11 MAINTAIN EXISTING CONTROL PROGRAMMES

Continue allocating funds for the control of wilding conifers at sites where initial control actions have been completed, especially sites that threaten areas with a biodiversity score of 12.5 or greater. Reassess any wilding conifer control

expenditure at sites that threaten areas with a biodiversity score of less than 12.5.

Explanation:
The continued allocation of resources to control wilding conifers at sites where control has already been undertaken is important to protect the initial investment at those infestation sites. This is especially important at sites with high biodiversity values.

At present (1999/2000) approximately 68% of sites with a biodiversity score of 12.5 or greater are funded for wilding conifer control. Approximately $236,000 and 3,686 staff hours were expended on all wilding conifer control operations in the South Island in the 1999/2000 financial year. It is not clear what proportion of this expenditure was at sites with a biodiversity score of 12.5 or greater.

ACTION 12 SEEK FUNDING FOR ADDITIONAL CONTROL

Seek funding for wilding conifer control at new sites listed in the schedule, especially those that threaten sites with a biodiversity score of 12.5 or greater. Prepare detailed funding bids for all sites in the order of priority listed in the schedule. Include the costs of controlling other plant pests at these sites in funding bids. (Note this is likely to require a 250-300% increase in funding).

Explanation:
There are many sites at which no wilding conifer control has been undertaken. Ideally all wilding conifers (and other weeds) at sites with a biodiversity score of 12.5 or greater should be controlled.

Estimates of the resources required to effectively control wilding conifers at all infestation sites are difficult. Likely control costs are influenced by many factors, many of which are difficult to determine without detailed information about the extent and density of wilding conifer spread at each site. Accurate estimates of the cost of implementing the strategy would require a more detailed site-by-site assessment of the costs of control.

However, general estimates of the per-hectare costs of removing varying densities of wilding conifer spread are available (see Section 5.4). Using these costs, it is estimated that funding for wilding conifer control would need to be increased to 250% to 300% of the present level of funding to effectively control wilding conifer spread that threatens sites in the South Island with a biodiversity score of 12.5 or greater.

This estimate assumes that such control would be spread over five years, so this increased level of funding would need to be maintained for at least that period. Furthermore, this estimate does not include new infestation sites, or further spread at existing sites, that will inevitably occur during that five year period. Neither does the estimate include the cost of controlling other plant or animal pests at those sites.

ACTION 13 REVIEW OF SCHEDULE

Review the Schedule of Infestation Sites appended to the Wilding Conifer Strategy regularly.

Explanation:
The Schedule of Infestation Sites appended to this strategy is based on information about wilding conifer infestation sites that was readily available at the time of writing (June 2000). The location and extent of wilding conifer infestations change continually. Regular review of the Schedule, and therefore the relative priorities for wilding conifer control, is essential. Such reviews should be coordinated by the lead Conservancy (see Action 6).

ACTION 14 IDENTIFY OPPORTUNITIES FOR CONTROL OVER WIDER AREAS

Identify opportunities for the coordinated control of wilding conifers over wider areas, including land not administered by the Department.

Explanation:
The effectiveness of wilding conifer control at many sites is influenced by the likelihood of reinfestation from seed trees on adjoining lands. Coordinated control of wilding conifers, across lands of all tenures and perhaps at sites with lower biodiversity values, would help ensure that such control is effective and sustainable.

'EFFECT ON ECOSYSTEMS' SCORES
WILDING CONIFERS (South Island)

Trial Assessment (May 2000)

Species	**Effect on Ecosystems**			
	A	**B**	**C**	**EOS**
Chamaecyparis lawsoniana (Lawson's cypress)	3	2	3	**8**
Cupressus macrocarpa (macrocarpa)	3	2	3	**8**
Larix decidua (larch)	3	3	3	**9**
Picea abies (Norway spruce)	3	2	3	**8**
Picea sitchensis (Sitka spruce)	3	2	3	**8**
Pinus contorta (contorta pine)	3	3	3	**9**
Pinus coulteri (big cone pine)	3	3	3	**9**
Pinus mugo (mountain pine) (incl. P uncinata)	3	3	3	**9**
Pinus muricata (bishop pine)	3	2	3	**8**
Pinus nigra (Corsican pine and Austrian pine)	3	3	3	**9**
Pinus pinaster (maritime pine)	3	3	3	**9**
Pinus ponderosa (Ponderosa pine)	3	2	3	**8**
Pinus radiata (radiata pine)	3	2	3	**8**
Pinus sylvestris (Scots pine)	3	3	3	**9**
Pseudotsuga menziesii (Douglas fir)	3	3	3	**9**
Sequoia sempervirens (redwood)	3	2	3	**8**
Thuja plicata (western red cedar)	3	2	3	**8**

NOTES: A=significance of change to community structure; B=ability to suppress regeneration; C=plant's persistance over time

- Ledgard's 'spreading vigour' and coning age assessments have be used to assist with the assessments.
- Only wilding conifers threatening DOC-administered land in the South Island are assessed.
- Total Score is EOS x 2 + BSR

'BIOLOGICAL SUCCESS RATING' SCORES
WILDING CONIFERS (South Island)

Trial Assessment (May 2000)

Species	Biological Success Rating						
	D	**E**	**F**	**G**	**H**	**I**	**BSR**
Chamaecyparis lawsoniana (Lawson's cypress)	1	3	2	2	2	0	**10**
Cupressus macrocarpa (macrocarpa)	1	3	2	2	2	0	**10**
Larix decidua (larch)	1	3	2	3	3	0	**12**
Picea abies (Norway spruce)	1	3	2	2	2	0	**10**
Picea sitchensis (Sitka spruce)	1	3	2	2	2	0	**10**
Pinus contorta (contorta pine)	1	3	2	3	3	0	**12**
Pinus coulteri (big cone pine)	1	3	2	2	2	0	**10**
Pinus mugo (mountain pine) (incl. P uncinata)	1	3	2	3	3	0	**12**
Pinus muricata (bishop pine)	1	3	2	2	3	0	**11**
Pinus nigra (Corsican pine and Austrian pine)	1	3	2	3	3	0	**12**
Pinus pinaster (maritime pine)	1	3	2	2	3	0	**11**
Pinus ponderosa (Ponderosa pine)	1	3	2	2	2	0	**10**
Pinus radiata (radiata pine)	1	3	2	2	3	0	**11**
Pinus sylvestris (Scots pine)	1	3	2	3	3	0	**12**
Pseudotsuga menziesii (Douglas fir)	1	3	2	2	3	0	**11**
Sequoia sempervirens (redwood)	1	3	2	2	2	0	**10**
Thuja plicata (western red cedar)	1	3	2	2	2	0	**10**

NOTES: D=maturation (seeding) rate; E=seeding ability; F=persistence of seed; G=effectiveness of dispersal; H=establishment/growth rate; I=vegetative reproduction

- Ledgard's 'spreading vigour' and coning age assessments have be used to assist with the assessments.
- Only wilding conifers threatening DOC-administered land in the South Island are assessed.
- Total Score is EOS x 2 + BSR

"NO GREEN NEEDLES"

- All wilding conifers should be removed (if possible) from each area covered by the control operation, so that the area can be regarded as 'clean' and re-inspection should not be required for several years. This may require different control techniques (such as hand-pulling and chain-sawing) to be used concurrently at the site, and good 'quality control';
- Seedlings and small trees should be removed first, so that when larger trees are subsequently felled they do not hide smaller trees;
- Outlier trees should be removed first, especially those trees at or near coning age;
- Hand-pulled seedlings should be removed completely from the ground, to minimise the risk of seedling survival;
- All trees or saplings that are too big to pull from the ground should be cut cleanly across the trunk as close to ground level as possible;
- Vegetation, litter, and soil should be scraped from around the base of the cut trunk to ensure that no branches or leaves (needles) remain attached to the trunk;
- The area covered by the control operation should be recorded and marked on a topographical map or GIS database;
- The number of hectares covered by the control operation, the density of wilding conifers per hectare and, if possible, the number or percentage of wilding conifers of each species removed during the control operation, should be recorded
- Always be conscious of 'quality control'. Trees not killed the first time are often much more difficult to remove the second time; and, trees not removed may produce seed and new wilding spread that negates all the initial control work.

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