Pacific Eco-Logic Ltd

Wilding Conifers in New Zealand:

Beyond the status report

Report prepared for the Ministry of Agriculture and Forestry

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Contents

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Cover photograph: wilding conifers on Molesworth Station (photograph taken by author**)**

Executive summary

This report summarises key components of the primary report[1]; and evaluates current and potential wilding conifer management in the context of the broader pest management system including the *Pest Management: National Plan of Action* (PMNPA)[2].

Species, impacts and risks

Ten introduced conifer species are responsible for most wilding conifers. While many of these species are not now planted commercially, some (e.g. radiata pine (*Pinus radiata*) and Douglas fir (*Pseudostuga menziesii))* still are. Some introduced conifer species provide significant economic benefits. This can complicate their management in locations where they are also environmental and/or economic weeds.

Contorta pine (*Pinus contorta*) is the most invasive introduced conifer species in New Zealand and is an "unwanted organism" under the Biosecurity Act. Other introduced conifers that produce unwanted wildings include Scots pine (*Pinus sylvestris),* Mountain pines (*Pinus mugo* subsp *mugo & Pinus* subsp *uncinata),* Corsican pine (*Pinus nigra),* Douglas fir, European larch (*Larix decidua),* Ponderosa pine (*Pinus ponderosa),* Muricata pine (*Pinus muricata),* Maritime pine (*Pinus pinaster),* and radiata pine.

A large area in the eastern South Island is affected by wilding conifers. In 2007 this was estimated to be approximately 805,000ha. This includes 185,000ha mapped as having a wilding cover and a 660,000ha that had received past control but were thought to still have wilding conifers (albeit at low levels). The area affected by wilding conifers in the North Island has not been fully mapped although it is estimated that approximately 300,000 hectares of land are affected by wilding conifers at various densities[3].

Wilding conifers grow faster and taller than low-stature indigenous vegetation. Indigenous ecosystems that are at particular risk from wilding conifer invasion include: tussock and other indigenous grasslands, alpine ecosystems, subalpine and dryland scrub and shrublands, frost-flats, wetlands, turf communities, geothermal areas, dunelands, ultramafic/serpentine areas, rockfields and herbfields, riparian areas, coastal margins, bluffs and cliffs. A number of the more invasive wilding conifer species (e.g. contorta pine, mountain pine and Corsican pine) are able to grow at altitudes above the treeline formed by indigenous forest species. Wilding conifers that grow above the native treeline cannot be replaced by native species as part of natural succession processes. In some cases wilding conifer spread may lead to the local extinction of native plant communities and populations of native plant and animal species. Soil properties and soil fauna are also changed when introduced conifers replace native ecosystems.

[1] Froude 2011 (Please refer to the reference list at the end of the document for the full reference citation)

[2] Ministry of Agriculture and Forestry 2011

[3] South island data from North et al 2007, North Island data from Paul & Ledgard 2011

Recently, the accelerated natural regeneration and spread of Douglas fir into indigenous ecosystems has become a matter of concern in some parts of New Zealand. Due to its higher shade tolerance Douglas fir is able to establish in mature beech forest (especially mountain beech), particularly where the beech canopies are more open and/or thinning and the understory is relatively sparse[4].

Many of the areas affected and/or vulnerable to wilding conifer spread are ecologically valuable protected lands (mostly managed by the Department of Conservation). Other affected public lands include those managed by LINZ and the Ministry of Defence. Large areas of pastoral lease land are affected by wilding conifers and some former pastoral lease land is also badly affected.

Areas managed for extensive pastoral farming based on indigenous tussock grasslands that may have been considerably modified by historical land management, can be highly vulnerable to woody (e.g. wilding conifers) and herb (e.g. *Hieracium*) weed invasion. The low economic value of these areas means that it can be very difficult for landowners to afford to control any wilding conifers. Where there are long-term seasonal soil moisture deficits (e.g. Canterbury foothills) trees (plantation and/or wilding) can reduce flows to levels that adversely affect in-stream aquatic ecosystems and existing direct uses of the water (e.g. water supply, irrigation). Wilding conifers also affect landscape values, especially those based on extensive low stature indigenous ecosystems (e.g. eastern South Island tussock grasslands).

Many of the worst wilding conifer infestations are associated with early/ legacy plantings, often by Crown agencies. Old Crown plantings include: erosion control plantings by the former New Zealand Forest Service (NZFS) in areas such as the Kaweka and Ruahine Ranges and Marlborough; NZFS research plantings at Craigeburn and Hanmer; and erosion control plantings by the former Ministry of Works and Development in areas such as mid Dome (Southland) and associated with the South Island hydro-electric power projects. In the Central North Island Volcanic Plateau many of the wilding conifers problems have come from early contorta pine plantings by the NZFS (e.g. Karioi) and private landowners. Today the cost of removing these and other source populations and the associated wilding spread can be very high. Leaving these areas sees costs of removal rise, often exponentially. Existing funding streams are not sufficient to remove these legacy plantings and the associated wildings. There are also risks of wilding conifer spread from some more recent plantings (e.g. Douglas fir spread from plantations is being observed in some areas).

Policy and management

The predictability and visibility of wilding conifers and the short-lived soil seed-bank means that it is more practical to manage their spread than that of many other pest plants. Prevention is the best management. The next best approach is early control before coning – S*titch-in Time-Saves–Nine.* In most cases it is also necessary to remove the source populations/plantings to remove ongoing re-infestation and prevent further spread. A key component affecting the success of any eradication/control programme is follow-up after

[4] Ledgard 2006; Davis et al. 2011)

initial eradication work. To avoid this step would potentially waste the large expenditure in initial control.

While there have been some significant successes, public agencies have insufficient funding for the effective long-term control of wilding conifers on lands they manage. Crown funding for wilding conifer control is severely constrained and may be further reduced. In several of the more problematic areas multi-agency/ community trusts have been established to improve co-ordination and funding. Ongoing research into improving chemical control tools has the potential to improve the cost-effectiveness of wilding conifer control.

Wilding conifer management can be confounded where beneficiaries of conifer stands (who are usually best placed to prevent or reduce wilding spread) do not incur the costs resulting from spread. Frequently these ongoing externality costs are instead borne by neighbouring land owners or the wider community. These costs can include direct control costs or the loss of opportunity to use the wilding infested lands for alternative purposes, such as grazing or conservation.

An example of where a beneficiary is not required to fund the externality costs has been created with the Emissions Trading Scheme (or the Permanent Forest Sink Initiative)[5]. In the case of the former scheme, there is no prohibition on landowners registering areas of wilding conifers (for carbon credits) as long as this is not contrary to provisions in Resource Management Act (RMA) plans or a pest management strategy prepared under the Biosecurity Act. There is no requirement to manage further spread.

In practice, existing RMA plans and regional pest management strategies (Biosecurity Act) are unlikely to have a significant impact on the eligibility of wilding conifers (except for contorta pine outside of Canterbury Region and mountain pine in Southland). As a consequence most landowners with wilding conifer stands that meet the definition of a post-1989 forest will be able to register those stands to gain carbon credits without any obligation to manage subsequent wilding conifer spread or transition to less spread prone species.

Wilding conifers do not respect property boundaries. Effective long-term control often requires a co-ordinated multi-organisation /multi-landowner approach, especially when the conifers in an area are on lands of different tenures. There is currently no national framework across all agencies within which to undertake prioritisation consistently so as to deliver greatest return on collective investment. Many people involved with wilding conifer management have expressed a strong desire for national co-ordination via a national strategy.

In making a national wilding conifer management strategy the first recommendation, it is proposed that this be a non-statutory strategy that is not constrained by the scope of the existing legislation. A variety of tools could be used for implementation. Given the broad range of interests at stake (including agricultural and forestry interests) MAF appears the logical choice to lead the preparation of the strategy. This is consistent with the PMNPA, which confirms the Ministry's role as overall leader for pest management systems. It is

[5] The Emissions Trading Scheme operates under The Climate Change Response Act; the Permanent Forest Sink Initiative operates under the Forests Act and associated regulations

important to note, however, that while MAF should, consistent with the PMNPA, lead strategy development, *implementation* of the strategy would need to be a broad, multi-party responsibility.

Wilding conifers (Douglas fir) spreading into tussock grasslands in Southland (Photograph taken by Lynne Huggins, Department of Conservation)

1 Introduction

This report was one of two reports on wilding conifer management in New Zealand that were commissioned by the Ministry of Agriculture and Forestry (MAF) Biosecurity in 2011. The original broad terms of reference for the primary (status) report[6] included: historical factors, current state, impacts, legislation and policy, current management, control, barriers to effective management/control, risks including likely future spread and implications, related land use issues, current research and potential opportunities. These terms of reference were expanded to include a series of case studies and an assessment of natural ecological changes and vulnerabilities for key at-risk ecosystems. As required, the primary report was prepared by drawing on existing published and unpublished information as well as face-to-face and telephone interviews with individuals and targeted meetings. The New Zealand Wilding Conifer Management Group (NZWCG)[7] was actively involved in the processes for preparing the report and the perspectives of the diverse membership are reflected in the report. Original data was not collected and projects were not independently audited.

Towards the end of the primary project this second report was commissioned. Its purposes were to: summarise key components of the primary report; and evaluate current and potential wilding conifer management in the context of broader pest management including the *Pest Management: National Plan of Action* (Ministry of Agriculture and Forestry 2011). While this report summarises parts of the primary report it also contains some additional policy-related content.

2 Background

2.1 Wilding conifers in New Zealand

In land management "*wildings*" are defined as the natural regeneration (that is the seedling spread) of introduced trees[8]. The term is usually applied to introduced[9] conifers, as they represent most of the major spreading forestry species of concern. To avoid confusion with other potential interpretations the term used today is "*wilding conifers*".

Introduced conifer species (particularly pines, Douglas fir, redwood and larch) have been planted in New Zealand over many years for a variety of purposes. These include:

- Timber (including firewood) production,

[6] Froude 2011 –The full reference for this and other citations are in the references section at the end of the report

[7] The NZWCG was initially established as a stakeholder oversight group for a research programme on South Island wilding conifers (funded by the Sustainable Farming Fund (Ministry of Agriculture and Forestry). The Group has more recently expanded its role to address policy and management

[8] Ledgard & Langer (1999)

[9] Introduced species are non-native species. Once introduced species are able to establish and breed to maintain populations in the wild they are known as naturalized species. In this context being "naturalized" is seen as a problem and is often the first step to an introduced plant becoming a pest plant.

- As a raw product for industrial processes such as pulp and paper production,
- Soil conservation/slope stabilisation,
- Research
- Shelter and landscaping.

Naturally regenerated or wilding introduced conifers have established from plantings established for each of these purposes. The earliest introductions of several wilding conifer species (maritime, radiata and Scots pines) occurred in the 1800s and by the early 1900s were being described by contemporary authors as invasive. However, spread of many species planted for shelter and timber (particularly in the South Island) took off from the 1940's. In some areas (such as the Mackenzie Basin) it took around 65 years for the initial plantings of Ponderosa pine, Corsican pine, Larch and Douglas fir to result in problematic spread (due, possibly, to the time taken for the appropriate mycorrhiza[10] to establish in the wild). Other reasons postulated for the significant spread of wilding conifers in the South Island in the middle of the 20th century relate to changes in vegetative cover that occurred as a result of destocking and changes in land management practices (particularly a decrease in burning) that occurred at the time.

In the North Island, contorta pine was seen invading large areas of the Central Volcanic Plateau by the 1960s with significant increases reported in subsequent decades.

Much of the ongoing wilding conifer spread is now several generations removed from the original source plantings. Examples of source plantings of introduced conifers include:

- Crown legacy plantings of contorta pine for erosion control purposes (e.g. Kaweka Ranges, Marlborough's Branch/Leatham catchments and Mid Dome in Southland);
- Crown legacy plantings of a variety of species for research purposes (e.g. Craigeburn and Hanmer Forests in Canterbury and Central North Island)
- Crown legacy plantings for timber production purposes (e.g. Central North Island)[11]
- Private legacy plantings of contorta pine and other spreading conifer species for shelterbelts and woodlots (on private and pastoral lease land)
- Private forest plantations are also providing a wilding conifers source in some locations.

While wilding conifers are regarded as pest plants or weeds that have various adverse effects and pose a series of environment risks; some species of introduced conifer are valued commercial species (and their continued use is economically important). These dual characteristics impose particular challenges for on-going management.

2.2 Ecological characteristics of key wilding conifer species

Key characteristics of ten introduced conifer species responsible for most wilding populations are summarised in Table 1

- *Contorta pine*

[10] Symbiotic fungal communities

[11] For example the Karioi Forest was originally planted by a Crown agency

As indicated in Table 1, *Pinus Contorta* is regarded as having the highest spreading vigour of all the wilding conifer species growing in New Zealand. It is a prolific seeder with seed dispersal by wind ranging from 60m from the parent site to up to 40km in very strong winds.

Contorta is a native of western North America where it is notable for: its ability to grow in a broad range of conditions, the ecological extremes covered by its range, and its pioneering ability to invade sites freshly disturbed by fire or storm events.

It was introduced into New Zealand in 1880. All four sub-species (*contorta, bolanderi*, *latifolia* and *murrayana)* have been planted*,* with the sub-species *contorta* being the most vigorous and associated with the most invasion problems.

By 1960 there was more than 10,000ha of planted pure or mixed stands. For a variety of reasons, including concern about its capacity to spread, commercial and non-commercial (e.g. erosion-control) planting of contorta pine ceased by 1980. It was declared a Class B noxious weed in 1983. Contorta pine spread had been evident in a number of locations before this time.

- *Douglas fir*

Douglas fir is another prolific seed producer and has light seed and cones that hang at the end of branches allowing seed to be readily picked up by the wind. Compared to introduced pines, Douglas fir is relatively shade tolerant. Douglas fir is able to spread into shrublands and regenerating native forests before canopies close. It is able to establish in mature beech forest (especially mountain beech, Figure 1), particularly where the beech canopies are more open/or are thinning and the understory is relatively sparse.

It is thought that a major reason for the observed increase in successful regeneration of Douglas fir in the wild is that there are now higher levels of the mycorrhizae specifically associated with Douglas fir in the environment. Douglas fir grown from seed dispersed away from planted areas are now more likely to be inoculated by the correct mycorrhizal fungi in their early years[12].

[12] For a detailed explanation see the full wilding conifer review document(Froude 2011)

Figure 1: Douglas fir seedlings inside mountain beech forest at Hanmer Forest, Canterbury (photograph by author)

- *Mountain pines*

Mountain pines grow at higher elevations than any other conifer, reaching 2400-2700m altitude. *Pinus mugo* subsp. *mugo* is a low stature plant with a multi-stemmed growth form. It is able to withstand down-sliding snow and debris because its base lies on the ground and ascending shoots emerge as far away as 10m from its root base (Jorgensen 2010). *Pinus mugo* subsp. *uncinata* is a taller tree up to 20m in height.

In New Zealand mountain pine has invaded subalpine and alpine areas above the native treeline in the southern South Island. Mountain pine has a low shade tolerance and in northern Europe (where it is also an invasive species) single species stands older than 100 years are rarely found except where there are very harsh conditions (soil, wind or salt). In

these situations mountain pine can be expected to form a permanent cover for hundreds of years[13] .

- *Scots pine*

Scots pine has a wide natural range through Europe and Asia. It can establish in a wide range of climate and soil conditions, including nutrient-poor soils. In New Zealand most Scots pine was originally planted for erosion control or timber production purposes. At Molesworth Station, Scots pine has been found to cone at altitudes above 1000m and establish from seed at least up to 1200m[14]

- *Other conifer species*

Radiata pine remains the most widely planted conifer species in New Zealand. While it is the least vigorous spreader it is probably the most drought-tolerant of the common conifers. It does not pose a major wilding problem in the South Island possibly because the cones are serotinous[15] and there is usually insufficient heat for them to open. Radiata wilding spread occurs in the North Island particularly in coastal and lowland sites and is common in Northland and the Marlborough Sounds.

A comparison of the key attributes of the relevant wilding conifer species is provided in Table 1.

[13] Jorgensen 2010

[14] Ledgard 2004a, b

[15] Serotinous cones are those that do not readily open on the tree until the tree is felled or strongly heated (by fire)

Table 1: Wilding Conifer Species Comparisons

Species common name	Species scientific name	Average age of significant coning yrs	Coning altitude limit for New Zealand	Spreading vigour	Shade tolerance	Palatability	Natural range
Contorta (lodgepole) pine	*Pinus contorta*	8	Above native treeline	Very high	intolerant (post fire regeneration)	High	W. USA
Scots pine	*Pinus sylvestris*	12	At native treeline	Very high	?	Moderate	Eurasia
Mountain pine	*Pinus mugo* subsp. *uncinata*	8	Above native treeline	High	?	Moderate	Europe
Dwarf Mountain pine	*Pinus mugo* subsp. *mugo*	8	Above native treeline	High	?	Moderate	Europe
Douglas-fir (Oregon pine)	*Pseudostuga menziesii*	12	1100m	Very high	moderate	Moderate	W. USA
Corsican (Black) pine	*Pinus nigra*	13	800m	High	intolerant	Least	Europe
European larch	*Larix decidua*	12	Not confirmed	Moderate	intolerant	High	Europe
Ponderosa pine	*Pinus ponderosa*	13	Not confirmed	Moderate	intolerant	Very high	W. USA
Muricata (Bishop) pine	*Pinus muricata*	12	Not confirmed	Low	Intolerant (post fire regeneration)	High	W. USA
Maritime pine	*Pinus pinaster*	10	Not confirmed	Moderate	Intolerant (post fire regeneration)	Very high	Mediterranean
Radiata pine	*Pinus radiata*	10	600-700m	Low	intermediate	Very high	W. USA

2.3 The spatial extent and density of wilding conifers

- *National extent*

There have been several projects that have attempted to map the distribution and possible density of all or some wilding conifer species for parts of New Zealand. The most comprehensive of these projects was a jointly funded LINZ/Ministry of Agriculture and Forestry Sustainable Farming Fund project to determine the extent, density category and age category of planted and wilding conifers in the South Island (with focus on the high country)[16]. Information was collected for that project during 2006 from the Department of Conservation, some forest owners, Ensis/Scion, Environment Canterbury, Marlborough District Council and Queenstown Lakes District Council.

Based on this information, the best estimate of the area of wilding conifers in the South Island was that in 2007 about 805, 000 ha were "affected" by wilding conifers. Of this, approximately 660, 000 ha had been subject to control over the last 30 years with very low current densities so they could not be mapped in 2007. Nearly 50,000 ha of land had also received some confer control in the last 30 years but conifer density was still sufficiently high to map in 2007. Another 110,300 ha were mapped as having a wilding conifer cover without significant control. Figure 2 shows areas with dense and sparse populations of wilding conifer as well as areas of past control.

In the North Island it is estimated that 300,000 ha are affected by wilding conifers at various densities[17] . As with the South Island there are large areas that have been subject to control operations over different periods of time.

[16] North et al. 2007

[17] Paul & Ledgard 2011

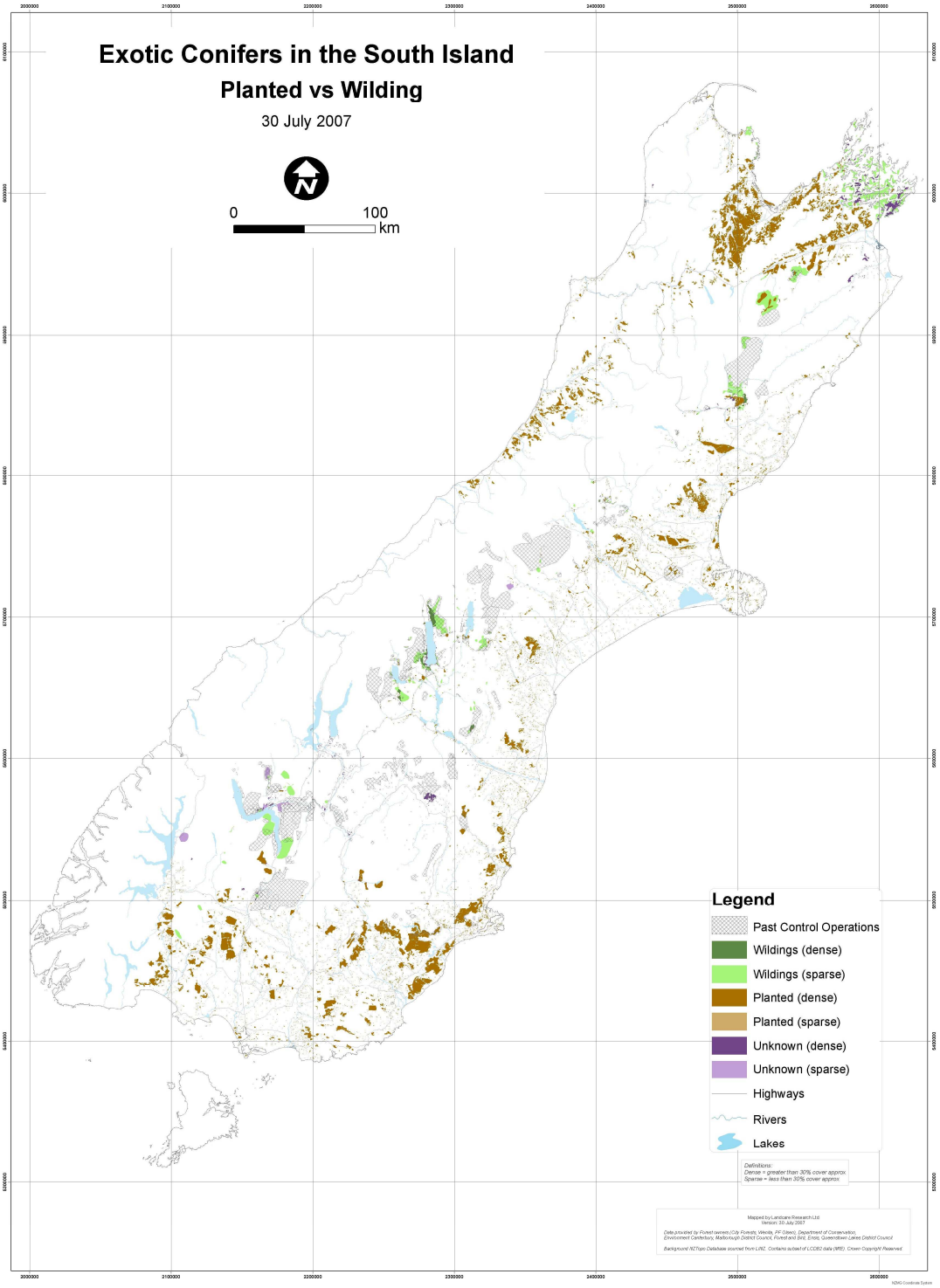

Figure 2: Introduced conifers in the South Island as in July 2007: showing areas where they had been planted, where they were wildings and where their origin was unknown. Also shown are areas of past control where current densities of wilding conifer are too low to map

- *Regional information*[18]

Many of the regional councils that include one or more species of introduced conifer in their regional pest management strategies (RPMS) have made some assessment of the extent of the wilding conifers within at least parts of their region. Some of these councils have set up a programme to monitor *change* in the extent of wilding conifers (and sometimes other attributes such as density, age category and species). As many of the wilding conifers and Crown legacy plantings are on lands administered by the Department of Conservation, the Department also carries out some monitoring. The full Wilding Conifer Status Report[19] summarises the available information on the situation with wilding conifers and their source populations[20] by region. This Information is in various forms and not comprehensive (nor is it necessarily comparable between regions due to different measurement methodologies).

Bay of Plenty – The Bay of Plenty Regional Council has commissioned several assessments of *Pinus contorta* extent and density in a 250,000ha part of the East Taupo, Upper Mohaka, Rangitaiki, and Waipunga catchments on behalf of itself and two other regional councils (Hawke's Bay and Waikato). The 2011 assessment[21] found that contorta pine extent had increased from 10,300ha (4%) in 2000 to 13,600ha (5%) in 2011. When looking at an expanded study area of 486,000ha, the same 2011 study found 27,400ha (6%) to be affected with *Pinus contorta*. As parts of this expanded area could not be directly assessed it was thought up to 8% of the area could be affected. Densities varied from 1 tree/ha to >250 trees per ha.

Hawkes Bay –Most of the lands seriously affected by wilding conifers in the region are managed by the Department of Conservation. The Department manages an estimated 97,000 ha for active wilding pine control (almost all in the Kaweka and Ruahine Forest Parks) with densities ranging from closed canopy to less than one stem per hectare. The main spreading species in the Region is contorta pine and almost all wilding conifer spread in the Kaweka and Ruahine Ranges is contorta pine. Wilding conifers in the Kaweka Range originate from revegetation projects undertaken by government departments because of concern about increasing erosion in the Tutaekuri catchment and downstream aggradation and flooding of the Heretaunga Plains [22].

Wanganui- Manawatu –The Ministry of Defence controls contorta pine on 63,000ha of defence land near Waiouru. After many years, the entire area is now controlled annually. The Tongariro- Whanganui -Taranaki Conservancy of the Department of Conservation (part of which is within the Wanganui-Manawatu Region) controls wilding conifers on 132, 236

[18] For a more complete description of regional patterns including references, please refer to the primary report Froude 2011

[19] Froude 2011

[20] The source populations are the original plantings, or where wildings from these original source populations are mature are producing seed they become secondary source populations

[21] Wildlands Consultants 2011

[22] Cunningham 1974

hectares on a three-year rotation. In the rest of the region there are a further 78,500 hectares that have been subject to control, some since the early 1990s.

Marlborough – Many south Marlborough catchments include areas seeded or planted with introduced conifer species for erosion control purposes in the 1960s-1970s. With 55, 000ha planted, the Branch/Latham catchment has been subject to more erosion control plantings than any other New Zealand catchment. While much is known about individual catchments the data has not been aggregated for south Marlborough. In 2004 1000 ha of the Marlborough Sounds had wildings at high densities (>50 stems per ha), while wildings at low densities (<1 wilding per ha) covered 24,000 ha)

Canterbury – A 2003 report[23] of 2.4 million ha of western Canterbury (i.e. the high country) estimated more than 60,000ha were infected with wilding conifers. Ten years on from the original assessment the area is being progressively resurveyed. The first five resurveyed catchments showed that where there has been control, the area of wilding conifers had reduced. However in the Waimakariri and Rakaia Catchments there had been significant increases in the area affected. (The total area within the five catchments studied identified with wilding conifer outliers was around 12,000 ha compared to around 8,500ha ten years earlier). Significant areas of wilding conifer source plantings in the Region include earlier Crown research plantings at Hanmer and Craigeburn Forest Parks. There were significant plantings in the 1970s and 1980s for soil conservation, amenity, landscaping and recreational purposes associated with construction of the Mackenzie Basin hydro scheme.

Otago – Figure 3 shows areas dense and sparse wildings in Otago Region as well as areas of past control. Currently the Department of Conservation treats about 58,000 ha of public conservation land in the Otago high country for wilding conifers. Another 78,000ha of public conservation land is considered to be threatened by wilding conifers (and sometimes other weed species). In the Wakatipu Basin area legacy, amenity, shelter and commercial forest plantings provide wilding conifer seed sources.

Southland – The majority of wilding conifers in Southland originate from old New Zealand Forest Service experimental and erosion control plots and commercial forests. A high profile area is Mid Dome where the original Ministry of Works soil conservation planting of 657ha planting has expanded to approximately 8000ha of medium to dense infestation (100 to 2000 stems/ha) with another 60,000 ha with a low-density infestation (1-100 stem/ha). Wilding conifers are present in many other parts of the region including the Takatimu Mountains, the Te Anau Basin, Blue Mountains and the Erye Mountains

[23] Old 2003

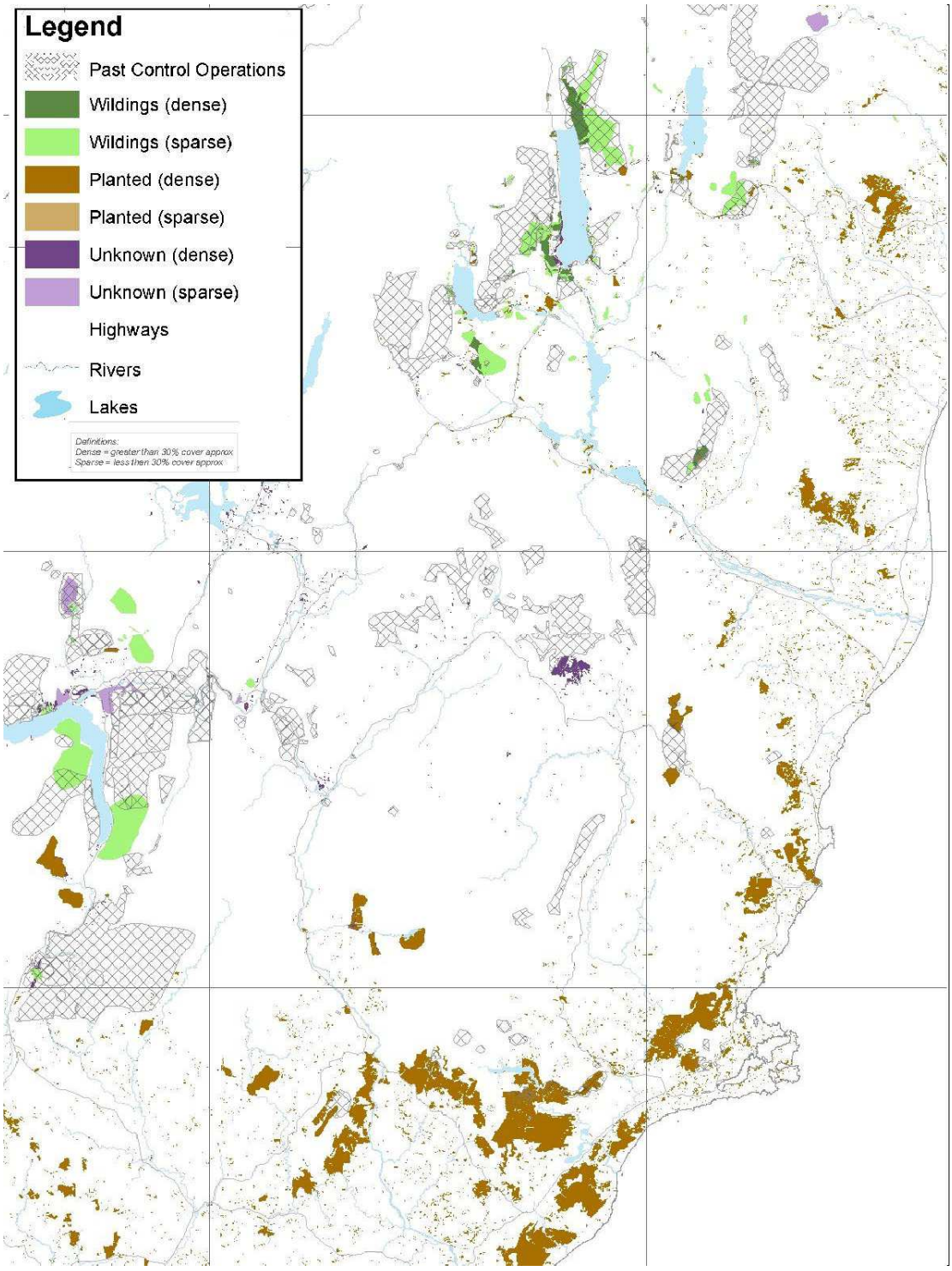

Figure 3: Introduced conifers in Otago Region as in July 2007: showing areas where the conifers had been planted, where they were wildings and where their origin was unknown. Also shown are areas of past control where current densities of wilding conifer are too low to map.

3 Impacts of wilding conifers

3.1 Effect on indigenous ecosystems and species

- *Effects on low stature indigenous vegetation*

Wilding conifers grow faster and taller than low-stature indigenous vegetation. Indigenous ecosystems that are at particular risk from wilding conifer invasion include:

- Tussock and other indigenous grasslands
- Alpine ecosystems
- Subalpine and dryland scrub and shrublands
- Frost-flats
- Wetlands
- Turf communities
- Geothermal areas
- Dunelands
- Ultramafic/serpentine areas
- Rockfields and herbfields
- Riparian areas
- Coastal margins, bluffs and cliffs.

Once wilding conifers invade low stature communities they shade out many of the native plant species and can change soil characteristics. Where the spread results in dense wilding conifer growth (usually from fringe spread) wetlands and riparian areas can become dry, especially in small catchments.

In some cases wilding conifer spread may lead to the local extinction of native plant communities. Examples of threatened communities include: the naturally stunted native shrubland communities on the Nelson Red Hills ultramafic substrates; and remnant shrubland and grassland communities in the intermontane basins of the South Island high country.

- *Effects on alpine ecological communities*

A number of the more invasive wilding conifer species (e.g. contorta pine, mountain pine and Corsican pine) are able to grow at altitudes above the local treeline formed by indigenous forest species (often mountain beech in eastern areas). Wilding conifers that grow above the native treeline cannot be replaced by native species as part of natural succession processes.

- *Effects on South Island drylands*

Disturbances resulting from human settlement have had a profound effect on the indigenous woody flora of the South Island drylands, eliminating many formerly widespread woody species and restricting others to small isolated remnants. Indigenous pollinators and seed dispersers for these woody species have also been extensively modified.

This means that the re-establishment of many formerly common woody native species is likely to be slow or non-existent. Those woody species that colonise the dryland grasslands

today must tolerate dry, droughty conditions, mammalian browsing, occasional fires and they must compete successfully with grasses.

Few indigenous species have these attributes, which are more common amongst introduced species. Some ecologists[24] have postulated that dryland secondary woody vegetation will be susceptible to dominance by various woody species such as pines, Douglas fir, sycamore, larch and birch over extended time periods, especially in sites that are drier, have more frequent disturbance, and have no/minimal seed sources for the taller indigenous species.

- *Effects on native forests*

Most wilding conifers have a low tolerance of shade and so do not pose a threat to established indigenous forests. Due to its higher tolerance of shade, Douglas fir is one of the few introduced conifer species that is capable of invading canopy gaps in native forests[25].

Douglas fir is able to spread into shrublands and regenerating native forests before canopies close. It is able to establish in mature beech forest (especially mountain beech), particularly where the beech canopies are more open/are thinning and the understory is relatively sparse. Where the canopy of mountain beech forest has thinned (because of old age or possibly an environmental stressor) that forest is more vulnerable to Douglas fir invasion. In that situation Douglas fir saplings can grow faster than beech[26]. Once Douglas fir reaches the canopy it provides an ongoing seed source that could lead to eventual replacement of the mountain beech forest by Douglas fir in that location. Computer modelling[27] indicates that at higher elevations Douglas fir has the potential to spread and significantly alter montane mountain beech forests.

- *Effects on soils and soil fauna*

Studies[28] have found that the conversion from native tussock grassland to radiata forest can lead to a reduction in: soil pH, exchangeable calcium, magnesium, potassium and iron. There can be lower levels of microbial biomass for carbon, nitrogen and phosphorus in the mineral soils under radiata pine, compared to tussocks reflecting lower soil organic matter inputs to the mineral soil. A number of the observed soil fauna differences between radiata pine and tussock grassland were associated with the soil differences.

- *Effects on protected areas*

The overall, the ecological characteristics of wilding pines means that they present significant risk to conservation land, particularly that which contains low stature vegetation. A 1998 Department of Conservation study[29] identified 260,000 ha of high priority protected tussock and alpine areas as threatened by wilding pines. Similarly, effects on high value conservation areas have been noted in regional studies. For example, the Bay of Plenty

[24] Walker et al. (2009)

[25] Ledgard 2006, Davis et al. 2011

[26] Thomas Paul, Scion, pers. comm.

[27] Meurk & Hall 2006

[28] Yeates & Sagar (1998)

[29] Owen 1998

study referred to earlier found that protected natural areas made up nearly 70% of the land affected by *Pinus contorta* spread.

- *Effects on indigenous species*

Where low stature indigenous vegetation is overwhelmed by wilding conifers, there may be local extinctions of individual species. For example populations of *Hebe armstrongii* in the Waimakariri Basin and *Hebe cupressoides* throughout the high country are threatened by wilding conifers. Native lizards and invertebrates of open communities can also be threatened.

3.2 Effects on pastoral farming and forestry

Wilding conifers typically do not pose a major problem for intensive pastoral farming which is characterised by improved and carefully managed pasture and relatively intensive stocking rates.

This is not the case for extensive pastoral farming based on indigenous tussock grasslands and other low stature indigenous vegetation that may have been considerably modified by historical land management practices (e.g. repeated fires and over grazing) and invasion by introduced plant and animal species. Where there have been repeated fires and/or overgrazing by domestic, stock, rabbits and/or ungulates the resilience of the indigenous grasslands has been reduced. These grasslands are more vulnerable to woody (e.g. wilding conifers) and herb (e.g. Hieracium) weed invasion. While sheep stocking above 0.5 stock units per hectare can provide control of wilding conifers, such rates are often not practical for "unimproved" grasslands[30].

Once wilding conifers spread onto such marginal farmland the active control required may be difficult for the landowner/ occupier to justify financially given the marginal worth of the land for grazing. This leads some landowners and occupiers to leave the wilding conifers to spread further including onto lands of other tenures. This spread can affect downwind areas farmed by others, and areas of conservation and landscape value.

3.3 Effects on water quantity

In many catchments, trees are helpful for reducing flood flows and reducing in-stream sedimentation and erosion processes. They can also be helpful for maintaining or enhancing water quality and aquatic habitats.

However, in some situations (especially in catchments where there are long-term seasonal soil moisture deficits e.g. Canterbury foothills), the effects of trees on surface water quantity can be adverse when taking account of existing interests in water availability. In these catchments interception of rainwater by trees can reduce flows to levels that adversely affect existing uses of water (e.g. water supply, irrigation, hydro generation) and/or in-stream aquatic ecosystems.

[30] As noted in Table 1 palatability of wilding pines to stock is variable. Corsican pine in particular has low palatability.

Data from a number of New Zealand catchment studies have shown that where pasture has been replaced by radiata pine forest, there has been a reduction in annual surface water yields of 30-81%, with the upper end of the range being observed in the dry South Island sites.

Different parts of the catchment make different contributions to water flow. Riparian zones, valley bottoms, hillside depressions tend to be the areas of greatest water storage. Trees planted or spreading into these areas would have a disproportionate effect on stream flow.

3.4 Other impacts

- *Landscape change*

The characteristics of wilding conifers and their potential to dominate indigenous vegetation have landscape/visual amenity as well as ecological consequences. These landscape impacts are generally greatest in landscapes currently characterised[31] by indigenous tussocklands and other low stature indigenous vegetation (e.g. South Island high country, Central North Island volcanic plateau).

Landscape impacts are perceived through the lenses of personal preferences and their significance depends on the values held by different people. A landscape dominated by northern hemisphere tree species (where it was once indigenous tussockland) may be preferred by some. To others such a landscape reduces the sense of openness, detracts from an environment that is unique to New Zealand and changes iconic vistas.

Further, both the South Island high country and volcanic plateau landscapes are important for tourism. Large-scale landscape changes could adversely affect the industry in these areas. Apart from the change to a unique and indigenous environment (and hence New Zealand's tourism product), there are potential tangible impacts on tourism. In the Wakatipu basin these effects could include blocking of views, changing of vistas (as trees grow above ridgelines) and impeding access to walking tracks and recreational areas (or increasing costs of maintaining access).

Wilding conifers could affect Maori cultural values in some locations including changing cultural landscapes as well as reducing water flows and river health/mauri.

- *Enhanced fire risk*

Fires in mature unmanaged wilding conifer stands are likely to burn hot and could potentially threaten adjoining land uses (including indigenous ecosystems and planted/managed forests).

[31] Box 2 of the full report (Froude 2011) summarises the scientific debate on the extent of pre-human grasslands below the treeline in the South Island

4 Future spread risk

The predictability and visibility[32] of wilding conifers means that it is more practical to manage their spread than that of many other pest plants.

Predictable elements include:

- Direction of spread – while this is mostly down-wind strong winds from unusual directions can be responsible for some long-distance spread)
- Age of seed production (usually 8-12 years)
- Risks associated with take-off sites (summits, ridges and slopes exposed to prevailing winds)
- The impacts on vulnerable areas (Ecologically valuable sites with low stature vegetation, light vegetation cover and light/no regular grazing)
- The soil seed-bank for introduced conifers has a relatively short life-span (up to five years), in comparison to weed species such as gorse (40 or more years).

The most recent work[33] on modelling future spread of wilding conifers uses the 2006 South Island wilding conifer dataset, a wilding conifer decision support protocol or scoring system[34] and a probability approach to test different assumptions. More work is needed to refine the model (including the decision support protocol[35] used) and improve the data sets used. In addition a suitable North Island data set is required. It is currently possible to define maximum and minimum risk but more work is required to develop the probability curves.

An assessment[36] of spread for one high country station near Queenstown found that while the station had been virtually free of wilding conifers up to the early 1970's, by 2003 one third of the southern part of the property was affected. Without control, a conservative assessment predicted that all of the station would have a significant wilding cover within 80 years. Adjoining protected areas would be likely to be occupied by wilding conifers within 40-60 years. These types of assessment indicate that in the absence of sufficient effective intervention there would be a high risk of major vegetative change in the South Island high country and a number of other areas with low stature indigenous vegetation.

5 Management techniques and options

5.1 Management techniques

- *Mechanical and chemical control methods*

A variety of methods can be used for controlling wilding conifers, with the mix used for any particular operation being dependent on the size, density and location of the infestation, as

[32] Wilding conifers are usually highly visible before coning begins

[33] Thomas Paul at Scion, Rotorua

[34] Decision support system as in Appendix 4 of the full report (Froude 2011) and Ledgard 2008

[35] This is discussed in section 5 of the full report Froude 2011

[36] Norton & Ledgard 2007. The station size is about 1800 ha

well as existing and intended vegetation cover or land use, budget and personnel skills. Potential methods include:

- Burning
- Sheep grazing (at greater than 0.5 stock units/ha)
- Physical control - hand-pulling, ring-barking, felling using a chainsaw or scrub-bar (see Figure 5), mulching, digger. (Where only physical control methods are used all green foliage must be removed to prevent trees re-sprouting and becoming more difficult to remove the second time).
- Chemical application - foliar spray, cut-stump poisoning, stem poison, bark application of chemical and soil uptake of chemical.

Control operations can be ground or aerial based or a mixture of the two. Where wilding conifers are remote or ground access is poor, helicopters are often used. Helicopters can be very cost-effective where wilding conifers are present in low densities across a large area.

Figure 4: Felled wilding conifers on LINZ administered land on the western shore of Lake Pukaki (Photo taken by Sherman Smith, Ministry of Agriculture and Forestry)

- *Biological control*

Biological control using an agent that damages cones thereby reducing seeding and spreading vigour, has been suggested as a possible long-term solution to contorta. The major concern with any biological control for contorta pine, however, is that the agent could affect closely related pine species that are of great importance to the New Zealand economy, especially radiata pine.

The European pinecone weevil *Pissodes validirostris* has been identified as a potential biocontrol agent for contorta pine. However, the possibility that a cone insect could act as a vector for the fungus that causes pitch canker disease, *Fusarium circinatum*, is a critical impediment to the use of biological control for pines species in New Zealand[37]. While pitch canker is not currently in New Zealand, radiata pine, and especially the strains currently grown in New Zealand, are highly susceptible to the disease[38]. It is possible that the European pine cone weevil could shift hosts to radiata pine and associate with the fungus that causes pitch canker[39].

5.2 Management Strategies

- *Prevention*

The primary means of prevention are to appropriately manage: the planting of introduced conifers that may spread; and existing stands in at-risk locations. There are existing guidelines[40] on how to plant conifer species to minimise their risk of spread. Key points include the need to:

- Avoid planting on take-off sites (ridges and upper slopes exposed to especially the prevailing wind)
- Avoid creating a long axis of planting perpendicular to the prevailing wind
- Avoid planting upwind of vulnerable vegetation
- Using less spread-prone species around the planting margins.

- *Eradication*

Local eradication is possible with a well planned initial eradication operation and long-term systematic follow-up. If appropriately timed follow-up is omitted, it is likely that introduced conifers will regenerate or recolonise a site. This is a major risk where funding is sporadic.

- *Containment*

A strategy of containment can be the most appropriate approach for large inaccessible plantings of spreading introduced conifers, particularly where there are some boundaries that can be easily defended. This is likely to be the case, for example, in respect of some large areas that were planted or aerially -seeded for erosion-control purposes in the 1950's - 1980's that today's management agencies do not have the funding to remove (e.g. Branch and Leatham catchments in South Marlborough). In some cases removal may create other land management costs/ problems.

- *Managing for economic benefit*

Some landowners with dense infestations of relatively mature wilding conifers have considered various options for managing those stands for economic benefit. These options

[37] Brockerhoff et al. 2004

[38] Dick et al. 2004

[39] Storer et al. 04

[40] Ledgard & Langer 1999, Ledgard 2006

have included management for logs (often not an option with unmanaged stands), firewood, pulpwood, wood for local energy production, or more recently registration for carbon credits under the Emissions Trading Scheme[41]. Under any of these options landowners could transition to species with lower spread risk. Investigations to date however, suggest harvest will be seldom economic due to the poor quality of timber, difficulties of access and/or the (in the case of wood for energy) apparent low demand/interest for the product given alternatives.

5.3 Existing research

A Ministry of Agriculture and Forestry Sustainable Farming Fund (SFF) project on South Island wilding conifers was completed in 2010. That project included:

- Bringing together information from a variety of sources to compile GIS maps and a database of South Island wilding conifer extent (as at 2007);
- Developing preliminary models to identify locations at risk from future wilding conifer spread;
- Evaluating control methods; and
- Measuring (early) vegetation succession processes following different types of control in several locations.

The South Island Wilding Conifer Management Group was established to provide stakeholder feedback and oversight of the project.

The primary report[42] identifies a range of existing direct and indirect research programmes of relevance to wilding conifers. Current research efforts largely fall into one of two categories:

- Improvement of *management tools* (e.g. developing the "best" herbicide mixes; determining optimal control regimes; modelling potential future spread of wilding conifers). This research has the potential to significantly reduce long-term costs of wilding conifer control.
- Improvement in *understanding of ecological patterns and processes* and how these can be affected by wilding conifers. The research on natural ecological processes (including succession) in areas particularly at risk of wilding conifer invasion, along with research on the impacts of introduced conifers on above and below ground biota, helps managers better understand the wider environmental impacts and identify priorities for management.

6 Management Regime

The public policy response to threats posed to New Zealand's interests by wilding conifers is to provide for intervention, as necessary, in accordance with the Biosecurity Act 1993, the Resource Management Act 1991 and the Local Government Act 2002 and, in terms of the Crown's own land holdings, through the statutes administered by the Department of

[41] The Climate Change Response Act 2002

[42] Froude 2011

Conservation and LINZ and the operational plans of other Crown entities with major land holdings.

Through these means agencies seek to manage and respond to current and future risk.

6.1 The national pest management system and the Biosecurity Act

The primary means of managing specific pest plants under the Biosecurity Act is through pest management strategies, although the Biosecurity Law Reform Bill 2010 will introduce some new tools if and when it is passed.

- *Pest management strategies*

The current processes for preparing national pest management strategies are slow and expensive. Few such strategies have been prepared and none exist for wilding conifers (or any other plants). All region councils, on the other hand, have at least one regional pest management strategy (RPMS). In so far as these relate to wilding conifers, they vary considerably, reflecting different patterns of present occurrence, varying potential risk profiles, and different political contexts. In most cases the focus is on contorta pine although Southland also targets mountain pine. Several regional pest management strategies include provisions relating to wilding conifers more generally (e.g. Canterbury and Bay of Plenty Regional Councils).

Most strategies reviewed (excluding Canterbury) have specific rules for contorta pine control (removal required within a specified time) and in some places containment (preventing spread beyond a specified area). A RPMS can provide for direct control by the council or cost sharing with landowners. An example of this pro-active approach is provided by the Horizons RPMS, which contains a zero density objective for contorta pine within the Volcanic Plateau Control Area. In its most recent RPMS, Horizons has moved to directly control contorta pine on private rateable land within the Control Area. Other parties (Department of Conservation, New Zealand Defence Force, Karioi Forest and roading authorities) undertake control on lands they manage within the Control Area.

- *National Pest Plant Accord*

The National Pest Plant Accord[43] is an agreement between the Nursery and Garden Industry Association, regional councils and government departments with biosecurity responsibilities. Pest plants listed in the Accord have been determined to be unwanted organisms under the Biosecurity Act. This ensures that sections 52 and 53 of the Act (banning communication, release, distribution, sale and propagation) apply to these pest plants throughout New Zealand. The only conifer specifies listed in the Accord is contorta pine.

6.2 Application of the Resource Management Act (RMA)

Under the Resource Management Act regions are required to prepare regional policy statements and regional coastal plans, while district councils are required to prepare a district plan. In the context of wilding conifer management, district plans can provide for:

[43] New Zealand Government 2008

- Restricting or prohibiting the planting of species known to have a high spread risk in certain locations
- Addressing potential wilding conifer spread risk, impacts and management as part of the assessment and condition setting process for relevant resource-consent applications.

In reality district plans vary widely in how they address activities that could affect the distribution and density of wilding conifers. The most comprehensive provisions are found in the Queenstown Lakes District Plan. Under that plan, the planting of wilding conifer species most likely to spread (contorta pine, Scot's pine, Douglas fir, European larch, Corsican pine, radiata pine) is prohibited in the Rural Zone. Forestry is a discretionary activity and tree planting is a restricted discretionary activity (meaning that it will generally be regarded as appropriate but not necessarily in every location). There is to be no forestry or planning of exotic tree species above 1070m altitude.

Several councils prohibit the growing of some wilding conifer species in all or parts of the rural environment. In Southland, for example, the planting of contorta pine and mountain pine is prohibited in the "Mountain Resource Area". Similarly, the planting of contorta pine is prohibited in rural Central Otago and the planting of Scots pine and mountain pine is a "non-complying activity" (meaning that a consent can be sought but it is generally be regarded as inappropriate). The approach to wilding conifers differs between district plans, even within the same region. While a number of districts within the Otago Region use rules Clutha District Council has no relevant rules and relies on non-regulatory means to "encourage" prospective tree-planters to consider wilding conifer spread.

- *National Environmental Standard (NES) on Forestry*

Consultation and drafting processes are well advanced for a National Environmental Standard (NES) for Plantation Forestry. It is proposed that the wilding tree risk calculator[44] will be used for determining the activity status for new afforestation (planting on land not previously used for plantation forestry). Where the score is equal to or less than 11 then afforestation would have permitted activity status. For situations where the scores are between 12 and 16 the activity status is restricted discretionary. In those situations where the score is greater than 16 the activity status is prohibited. Replanting with different species that has a higher risk of spreading will not be covered by this proposed provision. This is because replanting in the same area is generally considered to be an existing activity although it could be argued that changing to a species with a higher risk of spreading is not an existing activity because the effects are different. The NES is not currently operative.

6.3 The Crown as landowner

The other significant existing public policy intervention is through the operational programmes of the Crown as a landowner.

[44] A number of factors that affect the risk of wilding conifer spread resulting from a planting of introduced conifers at a site are scored using the decision support system set out in Ledgard 2008. They are also in Appendix 4 in Froude 2011. The scoring protocols are such that the system does not apply equally to all parts of New Zealand

The largest central government expenditure on wilding conifer control is by the Department of Conservation. Current overall expenditure of the department is estimated at $3.5 million nationally.

The Ministry of Defence has been controlling wilding contorta pine over 63,000 hectares at Waiouru for 40 years. Current annual expenditure is $900,000.

LINZ spent $700,000 on woody weed control in the South Island high country in 2007/2008.

6.4 Local government and community responses

Regional councils fund wilding conifer control in accordance with provisions in RPMS and/or under their Local Government Act mandate to promote economic, social, environmental and cultural well being of communities.

The largest council expenditure on an annual basis is by Canterbury Regional Council ($300,000), followed by Horizons ($125,000) and then Environment Southland. Environment Southland made a large one-off contribution ($300,000) to the Mid-Dome project in 2006. Otago Regional Council is unusual in that while there are extensive areas of wilding conifers within the region, it does not spend any money on direct management activities. Queenstown District Council provides direct funding for wilding conifer control.

Community trusts focusing on wilding conifer control have been formed in several areas. They have typically been established in areas of extensive wilding conifer infestation, usually across lands of a variety of tenures. Councils and Crown agencies are involved in most cases and often provide funding and other support.

At this time the major community trusts are:

- Mid Dome Wilding Trees Charitable Trust
- Wakatipu Wilding Conifer Control Group
- Waimakariri Ecological and Landscape Restoration Alliance (WELRA)
- Marlborough Sounds Restoration Trust

There are also other community organisations that address wilding conifer control as part of a broader programme of environmental management (e.g. some branches of the Royal Forest and Bird Protection Society).

7 Policy Issues

The key questions to be addressed are whether the current policy and administrative framework is adequate to address wilding conifers impacts and risks; and whether the management regime as implemented primarily by central and local government is effective in meeting the policy goals. Landowners, land managers and forestry companies also have a critical role to play in implementing policy and taking their own actions to minimise wilding conifer spread.

If either the framework is inadequate or implementation insufficient the question to be resolved is how to enhance the management of wilding conifers to achieve an outcome that is in the overall best interests of New Zealand.

7.1 Planning and implementation

All pest management activity requires a planning stage and an implementation stage.

The planning stage typically requires:

- Objective setting
- Allocating management responsibility and identifying a lead agency
- Prioritisation
- Integrating and co-ordinating management
- Arrangements for monitoring and measuring progress/performance

Effective implementation requires sufficient resources over the time of the programme (including for follow-up surveillance and control).

7.1.1 Objective setting, perceptions and preferences

Objective setting for wilding conifer prevention and management can be complicated because, as noted earlier, although clearly plant pests in some locations, some introduced conifer species provide significant economic benefits. Even some wilding conifer stands may potentially provide economic benefit and/or may be valued by some for amenity reasons. In the context of the latter, people vary in their perceptions of what is natural (for particular areas in New Zealand) and in their visual preferences.

Decision-makers and the public vary in their perception of the impacts and risks posed by wilding conifers. For example, there can be a perception that when there are only a few trees, no control is needed, even though this is the most cost-effective time to intervene ("Stitch in Time Saves Nine"). An equivalent misperception is that once an area has been subject to an initial control programme and few, if any trees remain, there is no problem and no follow-up is needed. These misperceptions (based on an inadequate understanding of wilding conifer impacts and risks), can mean that limited funding is available for early control of wilding conifer spread and for follow-up control after the initial control operation. Landowners can be reluctant to undertake early control for the same misperceptions. Research has shown that the gap between perception and reality is reduced when people are informed.

7.1.2 Co-ordination

Wilding conifers do not respect property boundaries. Effective long-term control (beyond an individual property) often requires a co-ordinated multi-organisation/multi-landowner approach, especially when the conifers in an area are on lands under different tenures.

There are a number of public and private sector parties engaged in controlling wilding conifers. To get best return from these efforts a level of co-ordination and sharing of knowledge and resources is required.

While RMPSs attempt to achieve integration and co-ordination at the regional level their effectiveness has not been assessed. In some locations an interagency working group may identify leadership roles and provide some level of overall co-ordination for wilding conifer

control[45]. In some high profile areas (mid Waimakariri Basin (Canterbury), Mid Dome (Southland), Queenstown, Marlborough Sounds) community trusts (involving public agencies and the community) provide co-ordination and raise funds for the control of serious infestations of wilding conifers.

The public agencies generally considered that there was insufficient national and multi-region co-ordination. One interagency group that has been effective is the Central North Island Contorta Co-ordinating Committee. The New Zealand Wildling Conifer Management Group (includes people from a range of organisations) has been evolving from providing oversight of a research programme to a broader role.

7.1.3 Funding Issues

Wilding conifers can occur across vast areas and often in difficult to access terrain. This can make the cost of control high (for both private and public interests). There is currently a lack of well –proven techniques for the cost-effective removal of dense stands of wilding conifers, although good progress is being made in this area. In addition, costs of key control tools (helicopters and fuel) are high and have risen faster than inflation.

Public agencies have insufficient funding for effective long-term control of wilding conifers as required to achieve the outcomes that are in the best interest of New Zealand. Crown funding for wilding conifer control is severely constrained and may be further reduced. This limits the extent of control that can be undertaken and can limit the effectiveness of at least some control programmes. The Department of Conservation – the largest land manager in the country - has seen its budget and staffing significantly reduced, with currently unknown implications for wilding conifer control programmes.

Landowners and land occupiers, especially those with extensive areas of marginal lands, often have insufficient resources to effectively control wilding conifers on land they own/occupy. Of course, given scarce resources for pest management (and other spending priorities) it is always likely that funding will fall short of the optimum. That necessitates prioritisation. There is currently no national framework across all agencies within which to undertake that prioritisation consistently so as to deliver greatest return on collective investment.

One matter that needs to be addressed in any assessment of funding adequacy is the need to secure benefits already gained. Where wilding conifers have been removed from an area it is essential to undertake sufficient and regular surveillance and control to remove conifers missed and those that have germinated from the seed bank. To avoid this step would potentially waste the large expenditure in initial control.

7.1.4 Allocating management responsibility

Determining who is an exacerbator of wilding conifer spread and who is a beneficiary of wilding conifer control, and where the balance should lie in terms of allocating responsibility, is particularly problematic for wilding conifers. This is because of the multiple parties involved and the broad nature of benefits that flow from control. Beneficiaries

[45] For example a Canterbury wide working group involving the Department of Conservation, LINZ and Environment Canterbury determined that the Department of Conservation was best placed to lead wilding conifer control work in the Mackenzie.

potentially include farmers, irrigators, foresters, conservation interests, the tourism sector, hydro generators, municipal water supply authorities and others. Many of the same groups (but not necessarily all) can also be exacerbators. This will vary from place to place.

Currently beneficiaries of conifer stands and exacerbators of wilding spread (who are usually best placed to prevent or reduce wilding spread) do not always incur the full costs resulting from spread. Frequently these externality costs are instead borne by neighbouring land owners or the wider community. These costs can include:

- Direct (and often on-going) control costs
- Loss of opportunity to use wilding infested lands for alternative purposes (e.g. grazing)
- Loss of important previously-existing features (e.g. ecological attributes and landscapes dominated by indigenous species)

Also relevant is the historic nature of many of the most problematic plantings. The Crown (particularly through the former New Zealand Forest Service, New Zealand Forest Research Institute and the Ministry of Works and Development) carried out plantings for erosion control/ revegetation, plantation forestry trials and establishment, and hydro-electric power development mitigation[46]. Today extensive areas are affected by wilding conifers that have spread from these plantings. The Crown's obligations for managing these plantings and the resultant wilding conifer spread have not been clearly specified and accepted. In addition there are also private plantings (e.g. for shelterbelts and plantations) that have also resulted in ongoing wilding conifer spread.

To the extent that collective intervention is required, a key issue is who should lead such intervention. The chief options are:

- MAF as the government agent with overall leadership responsibility for biosecurity (and for agricultural and forestry interests)
- DOC as the Crown agency with responsibility for the conservation estate (including much of the high country land at risk)
- LINZ as the Crown agency responsible for managing pastoral lease land and various other lands of the Crown
- Regional councils, in recognition that major issues are present in only some regions and the nature and extent of management required varies significantly
- Leaving additional intervention to community organisations (with the public agency role primarily being to foster community responses).

Currently the default arrangement is generally that the relevant regional councils take responsibility where there is a constituency of support to do so. In some locations others take the lead. For example, the Department of Conservation leads wilding conifer control work in the Mackenzie[47]. Collective approaches emerge when sufficient incentive exists (a system reliant on motivation of individuals).

[46] Includes landscaping and erosion-control plantings such as those associated with reducing shoreline erosion when lake levels are raised

[47] See Appendix 11 (Case studies) in the full report (Froude 2011)

7.1.5 Monitoring performance

Understanding both the current situation and the effects of pest management programmes across a field of endeavour involving multiple players working largely independently, requires adoption of a consistent methodology for measuring and reporting. As was apparent from the review of information currently available, there is currently a lack of consistency in the monitoring and reporting of wilding conifer distribution and density. This means that it is difficult to build a national picture of the status of wilding conifers on lands of all tenures and to measure management performance.

7.2 Future risks, opportunities and management challenges

Further risks and challenges centre on three aspects:

a. Continuing land use and management changes
b. Complications caused by government policy responses to other issues that may have (unintended) consequences for wilding conifers.
c. Future research needs

Figure 5: Spreading wilding conifers around Lake Pukaki (Photo taken by Sherman Smith, Ministry of Agriculture and Forestry)

7.2.1 Land use and wilding conifers

While the source of much of the wilding conifer spread is old plantings, new and continuing plantings can and are causing new issues to arise. Wilding conifer spread is not just a legacy problem.

There are a variety of drivers leading to an increase in Douglas fir plantings in both the North and South Island. These include:

- recent changes to the New Zealand Building Code relating to the mechanical stress grading of sawn timber for use in house construction means that radiata pine grown in many parts of the South Island does not consistently reach a sufficiently high grade for it to be sold for use in New Zealand house construction (Section 13.3)
- a return to the pre-1994 situation allowing untreated Douglas fir to be used in New Zealand timber-framed homes
- some actual and potential disease risks for radiata pine
- ability to earn carbon credits via the emissions trading scheme (Climate Change response Act) or the permanent forest sink initiative (Forest Act and regulations)

This increase[48] is coming about as growers either change species after harvesting or grow Douglas fir in new locations.

There has been a recent increase in wilding Douglas fir, especially in protected areas[49]. In recent years, environment levels of the ectomycorrihizzal fungi specifically associated with Douglas fir have increased and this is thought to be a major reason for the observed recent increase in successful regeneration in the wild and spread into native ecosystems[50] (Section 2.1.4).

7.2.2 Complications caused by government policy responses and possible unintended consequences

The Government has introduced two carbon-management schemes that may have implications for wilding conifer management:

a. The *Emissions Trading Scheme (ETS)* - under the Climate Change Response Act 2002); and
b. The *Permanent Forests Sink Initiative (PFSI)* under the Forests Act 1949 and the Forests (Permanent Forest Sink) Regulations 2007.

The ETS provides for landowners to obtain carbon credits (New Zealand units) for:

- Post-1989 forests: Owners of new indigenous or introduced forests established after 31 December 1989 can apply to earn New Zealand units (NZUs) for increases in carbon stock from 1 January 2008. If the carbon in the forest is diminished then units must be surrendered. Participation is voluntary for post-1989 forest owners and if the forest is not registered the change in carbon stock defaults to the Crown
- Pre-1990 forests: These are forests that were already established as at 1 January 1990 and were in introduced forest species as at 1 January 2008. As long as pre-1990 forests are re-established after harvesting, or natural regeneration occurs, there are no

[48] Recent planting levels for all species have been relatively low (John Novis, Ministry of Agriculture and Forestry, pers. comm.

[49] Examples of areas affected include Southland, Nelson-Marlborough and Central North Island (Lynne Huggins, Kerry Brown, Nicholas Singers, Department of Conservation, pers. comm.)

[50] See section 2.1.4 of the full report (Froude 2011)

liabilities in respect of carbon. Participation in the ETS is mandatory when more than 2ha is to be deforested in any 5-year period from 1 January 2008. New Zealand units must be surrendered for deforestation.

Wilding conifers can be found on pre 1990 and post 1989 forest land as defined in the ETS. The tree weed exemption provision has removed a potential liability for landowners/agencies/organisations removing wilding conifers from pre 1990 forest land.

There is no prohibition on landowners registering areas of wilding conifers (for carbon credits (NZUs) under the ETS, as long as this is not contrary to provisions in RMA plans or a pest management strategy prepared under the Biosecurity Act. In practice, existing RMA plans and RPMSs are unlikely to have much impact on wilding conifers (except for contorta pine outside of Canterbury). As a consequence most landowners with wilding conifer stands that meet the definition of a post-1989 forest will be able to register those stands to gain carbon credits without any obligation to manage subsequent wilding conifer spread. This is an example of where a beneficiary is not required to fund the costs of externalities associated with their decision to gain some financial benefit from the wilding conifers on their property.

Where forests are registered for the PFSI under the Forest Act (obtaining credit for carbon sequestration via Kyoto Protocol Units (Assigned Amount Units or AAUs), there are no requirements that such registration not be contrary with provisions in RMA plans and/or RMPSs. It may be possible to exclude some wildling conifers from the PFSI as it could be argued that there may not have been active steps taken to create the eligible forest. Conversely it could be argued that the landowner facilitated natural regeneration by leaving wilding conifers/ not grazing an area. As with the ETS there is no requirement for those gaining AAUs to manage any subsequent wilding conifer spread.

With many landowners unable to afford removing existing wilding conifers, especially if they have been left for some years, registration for carbon credits may be a very attractive option. Once registered, a landowner may find there will be a significant financial penalty to pay to remove a wilding conifer forest. This penalty would be a major disincentive for removal. There is a risk that the effectiveness of community programmes to remove wilding conifers from some areas may be compromised if a number of landowners have registered their wilding conifers under the ETS or the PFSI.

It is possible to use funds obtained from an area of wilding conifer “forest” registered under the ETS to remove other areas of wilding conifers and to contain and then gradually replace an existing stand with species less likely to spread. While at least one property is using funds in this way as part of a long-term plan, there is no requirement for landowners registering wilding conifers in the ETS or PFSI to prepare and implement a long-term plan to manage spread. In addition some landowners who may have been prepared to remove wilding conifers (especially if resources had been available) may now register their wilding conifer forest in the ETS or PFSI.

Thus the Government policy may have an unintended consequence of creating an incentive for the retention of wilding conifers (and their subsequent expansion).

7.2.3 Tenure review of pastoral lease land

By 31 October 2010 tenure review had led to223, 000 hectares being transferred to freehold title and 209, 000 hectares retained to be managed by the Department of Conservation. Covenants were created for 8% (24, 795 hectares) of land transferred to freehold tenure. Overall the relatively productive low altitude terraces, fans and basins have been transferred to freehold title, while the colder, steeper higher altitude grasslands have become public conservation land[51].

Despite requirements for lessees to manage pest species, tens of thousands of hectares of pastoral lease land is affected by wilding conifers and some former pastoral lease land is also badly affected.

Two wilding conifer issues arise from the Crown Pastoral Land tenure review process.

- First, as observed by the Parliamentary Commissioner for the Environment, the tenure review process has treated the management of wilding conifers inconsistently. In some cases freeholded land has been tagged with a covenant requiring the freehold owner to manage wilding conifers and other weeds, while in other cases it has not.
- Secondly, land transferred to the DOC through the tenure review process has led to an increase in conservation land in areas of the South Island that are particularly vulnerable to wilding invasions. Some of the land transferred already contains wilding conifers at various densities. While there has been some additional funding to control woody weeds this does not cover all of the costs.

The Parliamentary Commissioner for the Environment's 2009 report on high country tenure review[52] recommended that sufficient additional funding be sought for a sustained woody weed eradication programme. That recommendation recognised that that the costs of wilding conifer control increased exponentially over time if the conifers are not addressed promptly and consistently, and that as eradication is labour intensive it could provide employment opportunities. To date the additional funding recommended by the Parliamentary Commissioner has not been secured.

7.2.4 Future research opportunities

A major priority necessary for the accurate monitoring of change and modelling potential future spread is the development of a clear baseline of current wilding conifer extent and intensity (species and density). It is suggested that a centrally managed spatial database, that allows updates and use of the data by multiple parties would provide most flexibility. This could be linked to a proposed national weeds distribution database. It is suggested that the requirements for the wilding conifers component of the database would need to be clearly specified by users along with standards for data collection and assessments of the accuracy of particular data sets.

[51] Section 11 of the primary report (Froude 2011)

[52] Parliamentary Commissioner for the Environment 2009

The electronic wilding conifer Decision Support System used for modelling future spread risks would benefit from some field assessments and refinements so that it is more appropriate for a wider range of situations[53].

Other useful areas for research include:

- The development of a scenario visualisation tool that can be used to generate landscape images of the consequences of different decisions and management regimes for wilding conifers for an area over time
- An assessment of the potential spread of Douglas fir and the associated impacts (especially on natural ecosystems)
- Evaluation of ecosystem responses following the control/removal of introduced conifers in different environments
- Development and use of sterile conifers.

The current systems for determining funding priorities for research can mean that it can be difficult to obtain funding for some wilding conifer research priorities.

7.3 Discussion and Analysis

The primary report[54] was commissioned as a status report-assembling the available and not-so-available existing information. As required, consultation with the stakeholder parties was an important part of the process and stakeholder agreement was obtained (via the New Zealand Wildling Conifer Management Group) for the recommendations arising.

Some of the key policy questions that emerged during the preparation of the report were:

a. To what extent does the current level of management effort address the wilding conifer problem nationally? Is the current level of effort on managing wilding conifers sufficient?
b. To what extent is the current level of effort appropriately targeted and prioritised?
c. To what extent is the current level of effort adequately co-ordinated?
d. To what extent could/should community groups/commercial sector interests do more if they were better incentivised and supported?
e. Is there sufficient sector group leadership being exercised to build a constituency of understanding and support for (i) sustained effort on wilding conifer control; and (ii) undertaking further wilding conifer–related research?
f. To what extent is cross-government (both within central government and across local government) policy and decision-making taking adequate account of wilding conifer risk issues and adopting a consistent and supportive approach?

While it might have been thought that the status report would have answered at least some of these questions, the available information was not sufficiently comprehensive or consistent at the national level to do this. Also, it is difficult to answer some of these questions in the absence of agreed national objectives.

[53] Further details are in section 13.2 of the full report (Froude 2011)

[54] Froude 2011

7.3.1 A national strategy for wilding conifers

The best way to address these questions would be to prepare a national strategy for wilding conifers. The first step in preparing such a strategy would be to develop national objectives and principles for wilding conifer management as these are needed before some of the questions can be answered.

This conclusion is consistent with feedback from number of people involved with wilding conifer management who have expressed a strong desire for national co-ordination via a national strategy for wilding conifer management. A national strategy could:

- Raise the profile of wilding conifer issues with government and within the wider community.
- Assist with assessing and prioritising funding bids on an on-going basis (or for a defined period)
- Help achieve consistency in approach to wilding conifers in central government policy making and regional pest management strategies and district plans
- Assist with priority setting for wilding conifer management across lands of different tenures.

The first recommendation from the primary report was to develop a national wilding conifer management strategy as a non-statutory strategy so that it would not be constrained by the scope of the existing legislation. A variety of tools could be used for implementation. This may include statutory mechanisms following processes set out in the appropriate legislation. There are also a wide variety of potential non-statutory tools available.

Potential statutory alternatives that could be considered include a National Pest Management Strategy (NPMS) the Biosecurity Act or a National Policy Direction(NPD), also under an amended Biosecurity Act. A NPMS is not favoured at this time because such strategies are slow and expensive to produce[55] and because their primary benefits (the ability to exercise coercive powers) are not necessary for the issues relevant to wilding conifers. The option of a NPD issued in accordance with the BSA is dependent upon the enactment of the Biosecurity Law Reform Bill 2010 currently before Parliament. That Bill provides, amongst other things, for the new instrument of a "national policy direction". As described in the Pest Management National Plan of Action 2011 (PMNPA), this instrument is intended to ensure that:

Pest management activities provide the best use of available resources for New Zealand's best interests and align activities where appropriate to national outcomes, by:

- *clarifying what the national outcomes are;*
- *clarifying requirements for using the regulatory instruments under Part 5 of the Biosecurity Act to manage pests and pathways;*
- *ensuring consistent application of these requirements nationally*

This instrument could best be seen as a tool that might be considered (during the strategy development) contributing to the implementation of a national wilding conifer strategy

[55] It is acknowledged that some simplification of process for preparing pest management strategies is included in the Biosecurity Law Reform Bill 2010 currently before Parliament.

rather than being the strategy itself. This is because a national policy direction could perform some but not all functions required by a national strategy.

7.3.2 Lead agency for strategy preparation

Potential agencies for leading the preparation of such a strategy seem to be limited. By definition, the development of a national strategy needs to be coordinated at a national level.

There are two main candidates: the Ministry of Agriculture and Forestry (MAF) and the Department of Conservation. Given the broad range of interests at stake (including agricultural and forestry interests) MAF appears the logical choice. This is consistent with the PMNPA, which confirms the Ministry's role as overall leader for pest management systems including:

- Promoting alignment of pest management activities within the whole biosecurity system
- Facilitating the development and alignment of national pest management plans
- Promoting public support for pest management
- Facilitating communication, co-operation and co-ordination of those involved in pest management to enhance effectiveness, efficiency and equity

While MAF should lead this strategy development, the implementation of the strategy would need to be a broad, multi-party responsibility. In that context MAF is likely to have a limited role beyond monitoring strategy implementation and perhaps some residual Crown liabilities. Again, this is consistent with the leadership functions described in the PMNPA, which also sees a regional leadership role for regional councils and functions for many other organisations to be carried out in respect of particular organisms, processes, pathways and places.

7.3.3 Strategy development process

Decision-making principles of the PMNPA that relate to the process for preparing a non-statutory strategy include the following:

- *Decisions will be made by those best placed to make them.*
- *Decision-making processes will include those whose accountabilities and interests are affected.*
- *Participants will be supported to understand who is responsible and the processes used to make decisions.*
- *Decisions will be timely, transparent and communicated to those affected.*
- *Decision-making will take into account tikanga Māori and kaitiakitanga of tāngata whenua.*

These principles indicate that the national wilding conifer strategy would need to be developed collaboratively with key stakeholders.

7.3.4 Strategy content and implementation tools

The content and implementation tools would need to be determined as part of the strategy development. However, based on the issues identified[56], as a minimum it should address:

- Objectives/outcomes sought
- Identification of priority areas for wilding conifer management (or how these should be determined)
- The level of funding required to effectively eradicate/control wilding conifers in priority areas
- Scenarios of future risk and how these should be addressed
- How costs should be apportioned between different parties in different situations
- Mechanisms for securing commitment of parties to the strategy and its implementation.
- Future management options and responsibilities for Crown legacy plantings and the associated wilding conifer spread.
- The meaning of "good neighbour" in the context of wilding conifer management
- The management of plants that both behave as environmental pests and provide economic benefits (usually in different places)
- Conflicting government objectives that may hinder the appropriate and timely removal of wilding conifers on private land, including those associated with the Emissions Trading Scheme
- Obstacles hindering effective community action in respect of wilding conifer management
- Raising community and decision-maker awareness of the potential impacts of wilding conifers and management regimes required
- Options for reducing wilding conifer risks associated with new planting and replanting
- Research requirements and monitoring protocols

8 Conclusion

Wilding conifers and their actual and potential effects have been studied extensively over the years. However, while we know much about wilding conifer risk we do not have a clear national picture of just how successful current management is nor whether the existing arrangements will be adequate for the future. Certainly there are many examples of good progress in particular areas. In other areas, however, studies indicate a growing problem.

We are able to predict potential wilding spread (although the methodology for doing this does require refinement). The characteristics of wilding conifers mean that unlike many other pest plants, control is generally practical and technically feasible. Although there is ongoing work to refine and improve control tools (especially for dense infestations) the basic technical (mechanical and chemical) control methods are well known and proven. One matter that is well known is that early action (*Stitch in Time, Saves Nine)* is highly cost-effective. A failure to respond at an early stage can lead to the costs of control escalating exponentially. Conversely a failure to follow-up after initial control means that the initial control gains are likely to be lost.

[56] In this and the primary report (Froude 2011)

While much of the legislative/ policy framework is in place, further improvements are required to address matters such as: the impact of the carbon management policy framework on wilding conifers; and the biosecurity policy/management framework for species that both provide economic benefits and pose biosecurity risks. Some mechanisms have still to be enacted (e.g. Biosecurity Law Reform Bill 2010).

Many of the other issues relate to implementation. The implementation of the existing policy framework is variable, especially for regions and districts. Collective actions (e.g. via community groups) have emerged to try to address problems in areas with high densities of wilding conifers. What are most needed are:

- *Leadership, co-ordination, and prioritisation;* and
- *Increases in resourcing and effort*.

Recommendations seek to respond to these needs. These recommendations have been refined and endorsed by the New Zealand Wildling Conifer Management Group

9 Key recommendations

1. That a non-statutory national strategy be prepared for wilding conifer management. The issues and options in the full report[57] provide a framework for the strategy. Matters that should be addressed include:
    a. The administration and implementation of the relevant legislation and national policy;
    b. Economic aspects including levels and sources of funding;
    c. Priorities for management on lands of different tenures;
    d. Education, research and monitoring (including standards for assessing and reporting change);
    e. Co-ordination across legislation and between organisations:
    f. The management of Crown/regional council/private legacy plantings and their wilding conifer offspring.

    This strategy could be implemented using a variety of statutory and non-statutory mechanisms.

2. That the Ministry of Agriculture and Forestry be the lead agency for preparing this strategy given its biosecurity functions, including the administration of the Biosecurity Act.

3. That stakeholder involvement in the strategy preparation process be formalised using a stakeholder forum and/or advisory group. The existing New Zealand Wildling Conifer Management Group could provide an appropriate stakeholder forum.

4. In the context of developing and implementing recommendation 1, it is recommended that:

[57] Froude 2011. This report also provides an explanation of the reasoning behind each of the recommendations

a. An accord[58] be developed between the forestry industry, Local Government New Zealand (on behalf of councils), Ministry of Agriculture and Forestry, Department of Conservation and LINZ. Arising out of the national strategy it may also be appropriate to develop other accords.

b. Further work be undertaken to determine the level of funding required to effectively control wilding conifers (in priority areas); how costs should be apportioned between different parties in different situations; and potential sources of additional funding.

c. Options for funding for the removal of problem Crown legacy plantings and the associated wilding conifer spread be investigated as a matter of good faith and prudent long-term environmental management

d. Options for redressing competing objectives that may hinder the appropriate and timely removal of wilding conifers on private land be further investigated, including those associated with the Emissions Trading Scheme

e. National policy direction [59] provide guidance about the scope of "good neighbour rules" in regional pest management plans in respect of plant species whose seed can be transported long distances

f. National policy direction provides guidance on how regional pest management strategies should treat species that are a resource in one place and a pest in another (e.g. introduced conifer species planted and managed for timber, and red deer farmed for many products; both are controlled in other locations)

g. Options for providing support for collective community action in respect of wilding conifer management be investigated as proposed in the National Pest Management Plan of Action

h. Tools be developed for increasing public and decision-maker awareness of the risks and impacts of wilding conifers, management needed and what has already been achieved

[58] The purpose of such an accord could be to develop protocols for the effective prevention and management of wilding conifers spread from planted forests. A recent example of such accord is the Clean Streams Accord 2003 (http://www.mfe.govt.nz/issues/land/rural/dairying-accord-may03.pdf)

[59] Under the Biosecurity Act (as is being provided for under Biosecurity Law Reform 2010 and proposed in the National Pest Management Plan of Action)

10 References

Brockerhoff EG, Hoffmann JH, Roques A 2004. Is biological control an option for the management of wilding pines (*Pinus* spp) in New Zealand? In: Hill RL, Zydenbos SM, Bezar C ed. Managing wilding conifers in New Zealand: present and future. Proceedings of a workshop held in conjunction with the annual conference of the New Zealand Plant Protection Society. Chateau on the Park, Christchurch, August 2003. New Zealand Plant Protection Society: Pp. 65-78.

Cunningham A, 1974. Headwaters of the Tutaekuri catchment. Study of an erosion problem in Hawke's Bay. New Zealand Forest Service Technical Paper No 62. Rotorua, New Zealand Forest Research Instsitute. 59 p.

Davis M, Coker G, Howell C, Henley D 2011. Establishment of *Pseudotsuga menziesii* and *Pinus nigra* seedlings in *Kunzea ericoides* and *Leptospermum scoparium* shrubland communities. New Zealand Journal of Ecology 35(3).

Dick MA, Horgan GP, Bain J 2004 Pitch canker- the threat to New Zealnd. In: Hill RL, Zydenbos SM, Bezar C ed. Managing wilding conifers in New Zealand: present and future. Proceedings of a workshop held in conjunction with the annual conference of the New Zealand Plant Protection Society. Chateau on the Park, Christchurch, August 2003. New Zealand Plant Protection Society: Pp. 79-95.

Froude, V.A. 2011. Wilding conifers in New Zealand: status report. Report prepared for the Ministry of Agriculture and Forestry. Pacific Eco-Logic, Bay of Islands. 206p.

Jorgensen H 2010. NOBANIS-Invasive alien species fact sheet-*Pinus mugo*. From: Online Database of the North European and Baltic Network on Invasive Alien Species-NOBANIS www.nobanis.org Date of access 6 December 2011.

Ledgard NJ 2004a. The rise and fall of introduced conifers on Molesworth Station. http://www.wildingconifers.org.nz/index.php?option=com_content&view=article&id=13:molesworth-a-case-study&catid=7:case-studies-2007&Itemid=19 Accessed 6 December 2011.

Ledgard NJ 2004b. A strategy for control of wilding conifers in South Marlborough. A Forest Research Contract Report Prepared for Marlborough District Council. Christchurch, Forest Research. 45 p.

Ledgard NJ 2006. Douglas-fir wilding spread and mitigation of risk. New Zealand Douglas-fir Cooperative Report No 50 Ensis Scion.

Ledgard NJ 2008. Assessing risk of wilding spread. New Zealand Plant Protection 61: 91-97.

Ledgard NJ, Langer ER 1999. Wilding prevention. Guidelines for minimising the risk of unwanted wilding spread from new plantings of introduced conifers. Christchurch, Forest Research. 21 p.

Ministry of Agriculture and Forestry 2011. Pest management national plan of action. Wellington, Ministry of Agriculture and Forestry. 38 p.

New Zealand Government 2008. National Plant Pest Accord.

North H, Ledgard NJ 2005. Modelling wilding conifer spread and control. Landcare Research Contract Report LC 04/05. Prepared for Environment Canterbury. Christchurch, Landcare Research. 27 p.

North H, Bartie P, Ledgard NJ 2007. Wilding conifer project report, July 2007: Objective 1 (mapping /risk assessment). Report for the New Zealand Wildling Conifer Management Group. 3 p.

Norton DA, Ledgard NJ 2007. Past, present and future status of wilding conifers, Mt Dewar Station, and future control costs. Christchurch, School of Forestry University of Canterbury and ENSIS. 33 p.

Old A 2003. Report on exotic wilding tree spread within defined areas of the Canterbury high country. Report No. U03/55. Christchurch, Environment Canterbury. 16 p.

Owen SJ 1998. Department of Conservation strategic plan for managing invasive weeds. Wellington, Department of Conservation. 86 p.

Parliamentary Commissioner for the Environment 2009. Change in the high country: environmental stewardship and tenure review. Wellington, Parlimentary Commissioner for the Environment. 92 p.

Paul T, Ledgard NJ 2011. Impacts of wilding conifers and their control on grassland and shrublands in New Zealand. Ecology in the Heartland Conference, 28 August -1 September 2011, Rotorua, New Zealand Ecological Society.

Storer AJ, Wood DL, Gordon TR 2004. Could biological control of wilding pines increase the potential for damage by the pitch canker pathogen? In: Hill RL, Zydenbos SM, Bezar C ed. Managing wilding conifers in New Zealand: present and future. Proceedings of a workshop held in conjunction with the annual conference of the New Zealand Plant Protection Society. Chateau on the Park, Christchurch, August 2003. New Zealand Plant Protection Society.

Walker S, King N, Monks A, Williams S, Burrows L, Cieraad E, Overton JM, Price R, Smale M 2009. Secondary woody vegetation patterns in New Zealand's South Island dryland zone. New Zealand Journal of Botany 47(367-393).

Wildlands Consultants 2011. Review of *Pinus contorta* management in the East Taupo, Upper Mohaka, Rangitaiki, and Waipunga catchments. Contract Report No. 2613; Prepared for Bay of Plenty Regional Council. Rotorua, Wildland Consultants. 54 p.

Yeates GW, Sagar S 1998. Comparison of soil microbial properties and fauna under tussock-grassland and pine plantations. Journal of the Royal Society of New Zealand 28: 523-535.