

**Wilding Conifer
Management Report for
FLOCK HILL STATION,
WAIMAKARIRI BASIN,
CANTERBURY**



Plantations and wilding conifer spread on Flock Hill Station viewed from Bridge Hill

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EXECUTIVE SUMMARY

Conditions may make wilding conifer control difficult, but no job is impossible. It is a matter of resources and funding. There is a suite of techniques available for control, with an effective operation likely to involve application of a number of these.

While this report refers to the entire Waimakariri Basin, it relates most specifically to the spread of wilding conifers on Flock Hill Station. A lot of components within the report are pertinent to lands of any tenure within the Basin.

The threat posed by rampant uncontrolled spread of wilding conifers across the Basin is not questioned in this report. There is considerable documentation available which highlights the problems caused by wildings, some of which has been referenced in this report. Environment Canterbury has recognised some conifer species as plant pests in their Regional Pest Management Strategy. Therefore, as pest status is already established, the author has not included any consideration of benefits of retaining the trees. There is a significant environmental and economic cost associated with their spread and this report looks specifically at some of the options for control, likely costs, establishes some priorities for work within the Basin, and makes a number of recommendations for consideration by the parties involved.

Wilding trees within the Basin are most prevalent on public lands administered by the Department of Conservation, on lands surrounding Castle Hill Village and on the Flock Hill Station pastoral lease property. There are also a number of planted stands containing trees of great concern as sources of wilding tree spread. While these trees may be kept in check in the immediate area due to grazing pressure and farming practices, their potential to spread onto surrounding retired lands is already realised in many cases. Shelter belts containing lodgepole pine in particular are recommended for replacement or removal so that their long-term threat to surrounding lands can be eliminated before the damage becomes expensive and time-consuming to remedy.

There has already been considerable effort to control wilding trees in the area, especially by the Department of Conservation. These will be jeopardised unless there is a concerted effort to continue control and reduce the threat of reinfestation. Environment Canterbury is in a position that it can augment the Department's effort by encouraging and conducting control operations on neighbouring private or leasehold land. The objectives of such control would be to achieve environmental protection through weed control and restricting the extent of wilding tree spread in the Waimakariri Basin, while at the same time maintaining some economic viability of high country land by preventing further loss of potential due to weed encroachment.

Flock Hill Station contains many important areas supporting unique species of flora and outstanding landscape values. The extent of the wilding tree infestation on this property is sizable, with about 4000 hectares affected by wilding trees. The area threatened by spread from these trees is significantly larger which means that doing no control on the property is not a responsible option for management. Appropriate compartmentalisation of the infestation into control blocks with associated priorities will mean that containment and eventual elimination of the problem will be possible. However, this will not come without considerable expense and an imperative need for collaborative effort between Environment Canterbury, the Department of

Conservation and landowners. Ongoing maintenance work will need to continue at intervals for at least a further 12 years following initial control.

While the purpose of this report is to identify options for achieving protection of conservation values, the control of wilding trees on Flock Hill Station will have benefits for both conservation and pastoralism. As such there needs to be a compromise between the two objectives.

A strategic allocation of control budgets will be necessary to achieve the best possible environmental outcomes. The basis for this should be the different control blocks and their relative priorities as identified by this report.

The tables within this report outlining priorities, methods of control and estimates of cost are likely to be a valuable decision support tool for those organisations involved in wilding tree control in the Waimakariri Basin. They represent the key information for management, with the associated text providing supporting material used in justifying the recommendations made.

RECOMMENDATIONS

- Conduct control in accordance with the recommended control blocks, priorities, methods and responsibilities
- The objective of any control efforts should be eventual elimination, with the exception of well managed plantings
- Encourage a collaborative control effort on Flock Hill Station involving the landowners, land managers, Environment Canterbury and the Department of Conservation
- Organise and conduct a public day for lessees, land managers and interested parties to raise awareness of the wilding tree issue
- Encourage a programme of removal or replacement of spread prone species in shelter belts and planted stands on private property
- Encourage the University of Canterbury to actively participate in research on Flock Hill Station
- Lobby Central Government to financially support a collaborative wilding tree control effort in the Waimakariri Basin

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APPENDICES

Appendix A – Flock Hill Station Control Blocks

Appendix B – Flock Hill Station Map

Appendix C – Constitution Hill: modelling the spread of wilding conifers

Appendix D – Harvesting Investigation Report of PF Olsen Limited

ADDITIONAL ATTACHMENTS

CD-Rom containing electronic copy of the Report, field trip photographs and shapefiles of the Operational Control Blocks

1 CLIENT AND PROJECT SCOPE

David Hewson, Senior Resource Care Coordinator from Environment Canterbury, contacted the author in March 2007 to commission a report on the wilding tree situation on Flock Hill Station, Waimakariri Basin. The purpose of this is to recommend courses of action to manage the threat to biodiversity, water yield and landscape values of the area, which will provide justification for expenditure to control wilding conifers on the property.

As part of the project the author was also requested to consider the wilding tree situation on other lands within the Waimakariri Basin and describe any associated wilding tree control efforts of other agencies.

2 OBJECTIVES

Prepare a report assessing the wilding tree situation on Flock Hill Station to include:

- Past history of wilding invasion
- Document the present situation and extent of spread on Flock Hill and adjacent land
- Assess future implications and threats to biodiversity and farming if no control works are undertaken
- Recommend possible management options, identifying benefits, disadvantages and implications of the various options
- Provide indicative control/management costs for the options and estimate ongoing maintenance costs
- Show how the recommended work programme integrates into the wilding control programmes of the Department of Conservation and other agencies, highlighting any anomalies or conflicts with other agencies plans or programmes
- Recommend possible funding options and suggest how to implement the programme

3 METHODOLOGY

The author undertook site inspections of Flock Hill Station and the wider Waimakariri Basin area on three different occasions. An initial project inspection was carried out with David Hewson over the two days of 10-11 April 2007. These days involved ground based inspections of the western parts of Flock Hill Station, including walking up onto the western ridge of Broken Hill (also referred to as Constitution Hill). Vehicle based inspections of shelter belts on other pastoral lease properties were also undertaken at this time to provide an overview of the current situation. Site visits on the second day were cut short due to the onset of rain.

The area was visited again on 3 May 2007 with Scott Downs and David Fincham of PF Olsen Limited to consider the viability and feasibility of harvesting operations.

The third visit was conducted on the afternoon of 15 May 2007 with David Hewson. This involved ground based inspection of the Flock Hill Stream area, utilising a helicopter for access. This was then followed by an aerial inspection over that part of

the property extending from Winding Creek in the east to Craigieburn Forest Park in the west.

Observations from the field surveys were used to prepare recommended control blocks based on:-

- density characteristics
- predominant tree size
- access
- perceived priorities for control.

These are presented in section 14 – Operational Control Blocks.



Figure 1 – Mature wilding conifer on the slopes of the Torlesse Range, looking back across Flock Hill Station to the north-west with Helicopter Hill in the centre background (May 2007)

4 INTRODUCTION

Wilding trees represent one of the most serious threats to the biodiversity and large open montane landscapes that define the high country of the South Island. In this context we are referring specifically to the uncontrolled spread of introduced conifers. They can produce thousands of seeds after only 6-15 years of age, depending on species and site conditions, and these can be wind-dispersed distances up to or exceeding ten kilometres depending on the situation. Wildings are long-lived and capable of out-competing other plant species in nearly all communities except dense forest. As such they can rapidly change the ecology and dynamics of large areas of land.

Wilding trees are recognised as a significant threat to native plant communities, endangered species and important wildlife habitats (Harding 2001). They also impact on landscape, historic and cultural values, as well as economic and recreational opportunities. The realised impact on water yield is not fully understood, but as a general rule it is accepted that catchments containing greater than twenty percent full closed canopy cover will have a significant reduction in water yield (N. Ledgard, pers. comm.).

The protection or enhancement of the distinctive characteristics of the Canterbury region is a required environmental result for the landscape, ecology and heritage objectives of Environment Canterbury's Regional Policy Statement (Old 2003). The spread of exotic conifers in the high country is recognised by Environment Canterbury (ECan) as a significant factor creating disturbance to these characteristics, resulting in the replacement of indigenous grasslands and shrublands with an exotic tree cover. Wilding conifer spread is also capable of affecting native forest ecosystems, with Douglas fir (*Pseudotsuga menziesii*) able to populate light gaps and grow in shade under canopy which could potentially result in substantial modification of areas of open beech forest.

The control of wilding trees is considerably more manageable than the spread of other problem plant weeds such as gorse and broom. This is due to its visibility, predictability and a relatively short longevity of seed banks. Conifers are clearly visible well before they reach coning age, especially when they occur in open grasslands. Their distinctive colouration and shape relative to native vegetation also makes them easy to detect in shrublands. It is usually easy to predict the direction of spread and likely invasion sites based on prevailing wind conditions and surrounding land use. This is easily verified by field inspection. As for the seed bank, conifer seeds rot very quickly meaning that ungerminated seed is not likely to remain viable for any considerable length of time. Regular maintenance following initial control operations and inspection of the areas at risk from spread should achieve elimination of the threat of wilding trees in a reasonably short period of time provided that all seed sources are removed. Depending on the circumstances, an effective wilding tree control operation could achieve elimination in 12 years compared to substantially longer timeframes for effective gorse and broom control.

A number of different organisations have been involved with the control of wilding trees in the Waimakariri Basin (referred to as the Basin). These include the Department of Conservation (DOC), ECan, Forest Research (now Ensis) and the

former Forest Service. A number of environmental groups have also conducted control efforts. Farm staff have removed trees as part of standard farming activities, while some properties have allowed individuals or other groups to remove trees from their properties.

While this report primarily focuses on wilding tree issues associated with Flock Hill Station, it also considers issues associated with other lands in the Basin. There are many different sources of wilding trees in the area. These are predominantly the plantations of the former Forest Service and Forest Research, along with shelter belts, homestead plantings and plantations on pastoral lease properties. The subsequent spread from these planted trees in turn has provided a source of trees for the further proliferation of wildings in the area. As with any naturalised weed, the regeneration from any externally sourced plantings will have a greater vigour for spread than the original parent trees. This is due to the regeneration having been conditioned to the environment since seed development. Having said this, once the longer lag period for planted trees has passed, both planted and naturally regenerating trees are likely to have a similar propensity for spread.

5 BACKGROUND

ECan's Regional Pest Management Strategy (2005) recognises the problems associated with the natural regeneration of wilding spread into unmanaged areas with existing land use values, or where the future land use options have yet to be decided. One of the purposes of the Strategy is to address wilding conifer spread, particularly that of lodgepole pine (*Pinus contorta*), associated with existing plantings.

The Regional Pest Management Strategy seeks to protect biodiversity values in targeted areas by reducing or eliminating the threats imposed by certain plants. It does not impose obligations upon landowners to control these plants, although ECan will encourage people to do so and provide technical and other support for control programmes. The Biodiversity Pest Programme under the Strategy deals specifically with pests whose principal threat is to biodiversity values in the Canterbury region.

Lodgepole pine has been classified as a pest in high-value environmental areas under the Biodiversity Pests Programme. Other species of conifer that have been listed as organisms to be controlled in targeted high-value environmental areas under this programme include:

- Mountain pine (*P. mugo*)
- Corsican pine (*P. nigra*)
- Scots pine (*P. sylvestris*)
- European larch (*Larix decidua*)
- Douglas fir (*Pseudotsuga menziesii*)

In conjunction with cooperating land occupiers, it is the intention of ECan to control these organisms in identified sites.

The District Plans of territorial local authorities, prepared under the Resource Management Act 1991, have the power to include land use provisions and non-regulatory measures to address wilding tree spread issues associated with new plantings

DOC is responsible for the control of plant pests on lands that it administers. It is responsible for significant areas of public conservation land within the Basin and is actively involved in wilding tree control. The amount of work that it conducts is limited by budgetary constraints, which would be the case with any organisation.

The legislation associated with pastoral lease lands does not address wilding trees specifically but requires land to be farmed in a good husbandry-like manner. The rampant unchecked spread of wilding trees is in conflict with this requirement.

Flock Hill Station

Flock Hill Station borders the Torlesse Range, which is the closest part of the Southern Alps to Christchurch. It is visible from surrounding public lands as well as a number of significant travel corridors, namely State Highway 73 (SH73) linking the West Coast with Canterbury, the Midland Railway Line and the Waimakariri River, the latter being well used by recreational boaters of all kinds. The landscape of the area is iconic, while the neighbouring Craigieburn Forest Park to the west is a favoured location for outdoor enthusiasts of all kinds.

Flock Hill Station covers an area of 13,946 hectares and is mainly endowment lease land of the University of Canterbury. It was vested in the Canterbury College by the Provincial Government in the 1870's to provide a source of funding for the college. The University leases the land to Flock Hill Station on terms similar to those in Crown Pastoral leases, while a small area is freehold for tourism purposes. The grazing rights have been sub-leased. The property is also used as a location for filming purposes, with scenes from the Lord of the Rings and the Chronicles of Narnia having been shot on site. Within the property an area of approximately 2175 hectares surrounding Broken Hill was retired from grazing under Soil and Water Conservation Plan Number 287.

As University Endowment Land, Flock Hill Station is not a pastoral lease in terms of the Crown Pastoral Land Act 1998. This means that the 'good husbandry' clauses of that Act do not apply with respect to land management.

The area most affected by wilding conifer spread is that immediately adjacent to the plantings on Craigieburn Forest Park, at Bridge Hill and around the homestead. Spread from these sources is concentrated around the sugarloaf landform of Broken Hill. This is the area that is focussed on for the purposes of this report, although some of the values associated with areas further to the east are considered due to the imminent threat of wilding invasion.

Existing vegetation

Formerly a forested landscape, the predominant vegetation is now grassland. Most of property retains some indigenous vegetative cover. It contains rare plants, wetlands, grasslands, shrublands and forest remnants.

Forest remnants remain in areas that were too difficult to farm and shrubland recovery occurs where grazing is less favoured. Much of the extensive grassland communities are depleted and open which makes them very susceptible to invasion from wilding trees, which are becoming an increasingly dominant vegetation community in large areas west and south of Broken Hill.

Much of the upper slopes of Broken Hill are relatively barren with largely vegetation-free screes and subsoils as a consequence of past grazing and burning practices. Some depleted forests remain on the montane slopes. Vegetation below this ranges from mountain beech forest through to open and closed shrublands to open short tussock grassland.

There are extensive areas of depleted short tussock grassland, particularly around Nomans Land and southern parts of Broken Hill.

Values

While Flock Hill Station has been greatly modified beyond its natural or original state, large parts retain high inherent nature conservation values. DOC has commissioned a number of reports over the years investigating the associated values, which include ecological, landscape, historic and cultural (Roozen 1996, Harding 1996, Lucas 1997). Despite these, no comprehensive ecological survey has ever been

done on the property as access permission and funding issues have meant that surveys could only be conducted in selected parts. The full extent of the associated values is therefore unknown, but a number of significant areas have been identified.

The Flock Hill lease lands are part of the dramatic and distinctive landscape of the Castle Hill Basin. The natural character of this landscape as a whole is of national importance. Geologically the land consists of glacial and fluvial infill, soft rock country (limestone) and isolated mountains (sugarloaf land system). The collective landscape of geological systems, water bodies and associated communities are highly valued to a great diversity of interests.

The Broken River karst area, which includes Cave Stream, is nationally important for its landscape, geological, geomorphological and botanical values. The Flock Hill scarp and its limestone tors are a distinctive landform. It is a refugia for many rare limestone plants such as the limestone forget-me not (*Myosotis colensoi*) and limestone harebell (*Wahlenbergia brockeriei*), and is the locality for *Seligeria diminuta*, a moss endemic to the Flock Hill tors. A number of rare animals, predominantly invertebrates, are also found at in this area. The limestone promontory of Flock Hill is of considerable cultural interest, with Maori rock drawings having been discovered nearby. The Avoca coal workings and associated tramway located in the lower reaches of Broken River have historical value.

The tussock grasslands and wetlands of the Slovens Stream, Puffers Stream and Tarnmoor areas in the eastern part of the property are key areas for endangered plants. They are rich in species, including the vulnerable and now relatively rare red tussock (*Chionochloa rubra*). The red tussock/*Schoenus pauciflorus* wetland community at Puffers Tarn is listed as a Special Site of Wildlife Interest (SSWI) and a Wetland of Ecological and Representative Importance (WERI). The wetland at Tarnmoor and its associated area of red tussock/*Carex secta* is also of significant importance. Extremely diverse shrubland communities near the streams are nationally important as they sustain several populations of the endangered *Helichrysum dimorphum*, while the *Coprosma intertexta* present is locally important and uncommon in the ecological district. Patches of remnant forest and depleted tussock grasslands in the area are also ecologically important.

The Mount Rosa area adjacent to the Waimakariri River in the north east of the property contains areas of bog pine (*Halocarpus bidwillii*) and dense *Olearia bullata* shrublands. These are both locally significant communities.

There are extensive areas of mountain beech (*Nothofagus solandri*) and shrubland on the property. The patches of remnant forest present are now rare in the Cass Ecological District and as such are significant. Forest remnants in the Broken River catchment contain species such as mountain totara which represent a skeletal record of the original vegetation of the area. Rata (*Metrosideros umbellata*), which is uncommon east of the Main Divide, can be found at Rata Stream. The presence of honeydew scale insect in the forests is important for supporting birdlife.

Nomans Land, immediately east of Broken Hill over Winding Creek, contains diverse and intact shrubland and forest remnants, the latter dominated by mountain beech and low *Coprosma linariifolia*. These are probably the most original plant communities

remaining on the property. This area also contains remnant snow tussock grasslands, bluff communities, and remnant kanuka (*Kunzea ericoides*) on the upper slopes which is rare in the ecological district. Nomans Land is a prominent landscape feature.

Broken Hill forms part of the scenic backdrop to travellers on the state highway, while its mix of beech forest, shrubland and tussock grassland has high conservation value collectively. The south part of Broken Hill and the Milliken Stream area contains patches of strongly regenerating mountain beech forest and significant areas of kanuka shrublands.

Winding Stream contains significant wetlands. It is also of considerable landscape importance as it is an unusual example of a high country meandering stream. This and other water systems on the property are regionally important for fish spawning.

The Basin in general is significant to Waitaha and Ngai Tahu. It is located on one of the traditional routes linking the east and west coasts.

While this section concentrated on the conservation values, it is important to acknowledge that there are also associated economic and scientific values. From an economic perspective the property retains pastoral, tourism and forestry potential which needs to be considered for the long-term viability of the property as a farm. Scientifically the property provides an important opportunity for research into wilding trees, high country forestry and long-term high country pastoralism.

6 SPREAD HISTORY

The spread of wilding conifers on Flock Hill Station can be attributed to two main sources. These are plantings and the associated secondary spread of resulting regeneration.

There are three distinctive conifer plantings which have contributed to the spread of wilding trees on the property. The locations of these are:

- Craigieburn Forest Park
- Immediately east and south of Bridge Hill on Flock Hill Station
- Surrounding the homestead and Flock Hill Lodge

While the first two of these are essentially in the same vicinity, the different tenure of the associated land is an important consideration for responsibility for control and it is therefore important to distinguish them.

The plantings around the Flock Hill Station homestead consist mainly of radiata pine, Douglas fir and Scots pine. These have led to significant spread in the area immediately adjacent along the northern slopes, with evidence of further spread on the north-east faces supported by the presence of radiata and Douglas fir. Modelling of wilding tree spread conducted by Heather North and Nick Ledgard (2005) suggests the spread from the homestead plantings is responsible for most of the trees in these areas.

The dates of plantings in the Forest Park and at Bridge Hill are well recorded. Exotic conifers were planted at Helicopter Hill as two year old stock from as early as 1963 and extending into the 1970s. Plantings in the area of Bridge Hill and Upper Hut Creek on both public and pastoral lease land were established from 1979-1985. The experimental plantings were part of a major research initiative, which is worth further attention for the purposes of this report as it provides an important background to the wilding tree spread over significant parts of the Basin.

A map displaying the relative spread attributed with these locations is contained within the North and Ledgard report titled 'Modelling Wilding Conifer Spread and Control' (2005). A copy of this map has been included in this report as Appendix C.

Forest and Range Research Station – Craigieburn Range

Reforestation research was conducted by the Forest Research Institute around the central eastern Craigieburn Range, with plantings located within the Upper Broken River Basin and the adjacent Upper Craigieburn Valley. The main objectives of the Craigieburn Range Field Station were numerous and varied, but focussed on studying the mountain environment and the physical processes affecting plant growth and contributing to erosional processes (Ledgard & Baker 1988). The integrated long-term research programme involved testing techniques for stabilising eroding surfaces and for this purpose evaluated the suitability of tree species for reforestation of formerly forested slopes.

A large number of different native and introduced tree species were trialled for stabilising eroded sub-soils and screes. Conifers excelled, with lodgepole pine and dwarf mountain pine proving to be the best suited for erosion control on a range of

depleted sites. The south faces of Helicopter Hill were planted with these two species in the late 1960s, with the long-term success of their establishment still evident today. Other successful conifers for establishing on depleted sites were Scots pine, Corsican pine, Ponderosa pine, Mountain pine, Douglas fir and European larch. All of these species now occur within the wilding spread emanating from the research area.

Another species which proved successful for general erosion control was green alder (*Alnus viridis*). This is another species that may turn up as a wilding tree and therefore vigilance needs to be maintained around areas where it was planted. Where it is observed to be spreading, the source and any regeneration should be considered for removal or replacement with non-spread prone species.

Risk Factors

Three major risk factors have been identified for wilding spread from exotic conifer plantings (North & Ledgard 2005). These are:-

- species choice
- siting
- surrounding land management, particularly downwind of seeding trees.

Conifers typically establish on lightly vegetated land such as grassland unless it is developed or subjected to grazing. Where source trees occupy relatively flat ground, seed dispersal by wind is largely limited to a distance of 100 metres from the source. This results in fringe spread which can be relatively easily controlled due to its confined nature. Conversely, conifers growing on exposed “take-off” sites such as ridges are capable of dispersing trees for great distances over the surrounding downwind landscape. Long distance dispersal from such sites can exceed ten kilometres and creates logistical issues for control that can lead to much higher costs.

The spread of wilding conifers is limited by a number of factors. These can be classified as natural and human-induced.

Natural factors

Prevailing wind direction and speed are a critical component of spread potential. The area at risk of infestation typically has a relatively long tail in the prevailing downwind direction, with shorter spread distances in the other direction (North & Ledgard 2005). This can be observed in Figure 2 which shows classic fringe spread around a mature lodgepole pine. The predominant spread is from a northwest direction, with spread in the opposite direction at a considerably smaller scale. This is due to the fact that in New Zealand prevailing northwesterlies are followed by southeast winds with the passage of a frontal system. The warm northwest winds open the cones and expose seed to wind dispersal. The rapid change to winds from the southeast occurs before the cones have a chance to close or become empty of seed, resulting in any remaining seed being dispersed in the opposite direction.

Distant spread is typically always in the prevailing downwind direction, although extreme one-off events can cause distant spread in other directions. Such events are infrequent, occurring perhaps every 10-20 years. There is a evidence to suggest that there have only been two major long-distance spread events from Helicopter Hill,

these being in 1977 and 1997 (N. Ledgard, *pers. comm.*). Distant spread can lead to far higher numbers of wildings due to the availability of a greater area of land.



Figure 2 – Fringe spread on the downwind side of a mature lodgepole pine on the western slopes of Broken Hill (April 2007)

Topographical influences on winds are also significant, with swirling and channelling responsible for spread that is atypical of the prevailing wind direction. Local winds are highly variable. The impact of them can be seen in parts of the infestation on Broken Hill. Seed has been deposited in areas as a consequence of local winds disturbing the main air flow. The resulting regeneration has then been able to expand in density in relative calm, as observed in Figure 2 of the Infill Basin Control Block. Such areas pose little immediate threat to other areas, although natural regeneration around the edges may be at increased exposure to prevailing winds.



Figure 3 – Aerial photo of the Infill Basin Control Block showing characteristics of increasing stand density due to siting in an area of relative calm (May 2007)

Different species of conifer have different site requirements and are therefore restricted by environmental factors. These include altitude, climatic conditions and soil types. The problem could have been significantly worse in the Basin as altitude has limited the spread potential of Corsican pine which is a major concern in other parts of the high country. The variability of climatic conditions also means that not every year will be favourable for seedling establishment. Fringe spread is therefore unlikely to be an annual event.

Human-induced factors

There are five main human-induced management factors which are recognised as having an impact on the spread of wilding trees. These are grazing, cultivation, oversowing and topdressing, fire and wilding removal operations. Three of these are significant on Flock Hill Station (N. Ledgard, *pers. comm.*).

Grazing or cultivation intensity and the level of competition from existing vegetation are considered critical elements limiting conifer seedling establishment. Competition from vegetation can be altered by fertilising and oversowing with competitive pasture grasses. In this manner it is sometimes possible to manipulate seedling establishment conditions. Grazing represents the most significant of these factors influencing areas of wilding spread on Flock Hill Station at present.

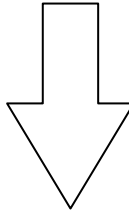
From a grazing perspective the most significant effect on wilding establishment is attributed to sheep, although rabbits, hares and cattle are also likely to have had some impact. Despite the grazing pressure from sheep having been extensive, with stocking rates typically less than 0.5 stock units/hectare, their impact has been dramatic. This is very noticeable upon consideration of the obvious difference in wildings around the retirement fence on Broken Hill. There are large numbers of mature trees and their associated fringe spread above the fence, while below it the trees are significantly younger and less dense with some notable exceptions. Another good indication of the effect sheep have on seedling establishment can be observed around some small enclosure plots on the property. Unfortunately grazing pressure was not maintained. The removal of grazing from the area between SH73 and the western faces of Broken Hill for a period during the mid 2000s resulted in a considerable increase in the growth of seedlings that had been previously suppressed for many years. This has been a significant contributing factor to the rapid spread of wildings in recent years.

Table 1 presents the spreading vigour of the main wilding conifer species along with their coning age and relative palatability to sheep grazing. (Refer to Table 2 for scientific names.) Spreading vigour varies according to species competitiveness, palatability seed production and seed weight. Declining spread vigour has a corresponding correlation with reduced number of seedlings associated with the species.

The area above Craigieburn Cutting was extensively burnt up to the retirement fence in the 1980s. The burnt area was subsequently oversown with grasses and legumes. Although the resulting pasture improvement was not as good as anticipated there has been a marked difference in wilding numbers compared to adjacent areas that were not burnt. The burnt and oversown area still contains significantly less wildings.

Wilding tree removal operations have been carried out intermittently since the 1980s, with more regular efforts occurring over the last 5-10 years. Large areas of the property have never had any control effort conducted over them, including that area of Broken Hill above the retirement fence.

Table 1 – Coning age for conifer species present in wilding spread on Flock Hill Station listed by common name in descending order of spread vigour, with associated palatability to sheep grazing listed by rank where 1 is most palatable and 7 is least palatable (from Ledgard & Langer 1999)

Species	Spread Vigour	Coning age (years)	Palatability	
Lodgepole pine	Most	8	3	
Scots pine		12	5	
Mountain pines		8	Unknown	
Douglas fir		12	6	
Corsican pine		13	7	
European larch		12	4	
Ponderosa pine		13	2	
Radiata pine		10	1	
		Least		

Wilding Tree Control Efforts

DOC expends considerable amounts of time and money annually in controlling introduced conifers on public conservation lands. It has already undertaken significant control of wilding trees in areas surrounding Flock Hill Station in recent years. Since 2004 there have been large-scale ongoing operations concentrated on the Korowai Torlesse Conservation Park, Craigieburn Forest Park, recent land acquisitions on Castle Hill Station and buffers on private land surrounding these areas. Work within Craigieburn Forest Park has been focussed on removing trees from the Broken River Ski Field and the Bridge Hill/Upper Hut Creek areas, with control to remove the extensive plantings on Helicopter Hill having been initiated in 2006. There have also been ongoing efforts over smaller parts of the conservation estate since before this time.

ECan has undertaken or coordinated significant amounts of work in the immediate area of Flock Hill Station and Craigieburn Forest Park, utilising staff, volunteers and contractors. There has also been work conducted at Mt Cheeseman and Porter Heights. An ongoing volunteer initiative involves paying clubs a small fee for the participation of their members in organised control days. Such days have the potential to attract large groups of people, with up to 150 individuals being involved in concentrated control efforts in specific areas.

ECan volunteers have been working in the Waimakariri Basin for eight years. Their efforts predominantly involve use of hand tools and have largely been concentrated on areas of recent infestation containing small trees at the furthest extent of the spread. In order to capitalise on the full value of volunteer efforts, ECan needs to ensure that appropriate maintenance work is carried out as well as instigate control of seed sources that threaten to reinvade areas they have controlled.

Prior to the recent control efforts a number of other small control operations were conducted. In 1989 a Forest and Bird (F&B) clearance operation targeted trees along the western ridge of Broken Hill from its south end to above Craigieburn Cutting. Another operation conducted by the Forest Research Institute in 1990/91 removed mostly mature trees from the lower slopes east of SH73. In 1997 a combined DOC/ F&B operation removed mostly mature trees on the slopes from Flock Hill Stream Saddle to the southern end of the western ridge. A number of other volunteer efforts were coordinated by DOC in the Basin from 1989-1996. A former lessee of Flock Hill Station also had school groups doing wilding tree control.



Figure 4 – Wilding trees spreading over the slopes behind plantings around the Flock Hill Station buildings (April 2007)

7 PRESENT SITUATION

The nature of the wilding tree infestation on Flock Hill Station and the adjacent Craigieburn Forest Park is on a large scale. The extent of spread on Flock Hill Station covers an area of approximately 4000 hectares, with a considerably larger area downwind of prevailing conditions at risk of infestation from this source of trees.

As part of a mapping exercise to baseline exotic wilding tree spread in the high country, ECan conducted a survey over about 220,000 hectares of the Waimakariri River catchment in 1998/99 (Old 2003). Considerable areas of plantation and spread were identified at Flock Hill Station, Craigieburn Forest Park, around Castle Hill Village and near Bealey, as well as shelterbelts on other pastoral properties in the Basin. The survey identified extensive areas of Flock Hill Station having outlier groups of exotic wilding trees present, along with considerable numbers of individual outlier trees.

This report redefines the extent of the problem on Flock Hill Station in light of further spread and ongoing control efforts. The exact areas involved have not been accurately mapped, but zones of infestation have been identified for the purposes of management. The extent of the situation over the wider area of the Basin has not been reassessed for the purposes of this report and the ECan survey report remains the reference for this, along with any revised mapping undertaken by the DOC.

The wilding conifer species present on Flock Hill Station and their respective frequency is presented in Table 2. Lodgepole pine is by far the dominant species and makes up a considerable proportion of the spread. The uncontrolled spread of Douglas fir is likely to impact on a greater range of environments though as it is more shade tolerant than the pines. It is therefore capable of invading areas of native forest and regenerating shrublands.

Table 2 – Common and scientific names for conifer species present in wilding spread on Flock Hill Station, listed in descending order of frequency

Common name	Scientific name	Frequency
Lodgepole pine	<i>Pinus contorta</i>	Extensive throughout
Dwarf mountain pine	<i>Pinus mugo</i>	Common throughout
Scots pine	<i>Pinus sylvestris</i>	Common throughout
Douglas fir	<i>Pseudotsuga menziesii</i>	Common throughout
Radiata pine	<i>Pinus radiata</i>	Common on northern slopes
European larch	<i>Larix decidua</i>	Occasional throughout
Corsican pine	<i>Pinus nigra</i>	Occasional at low altitudes
Ponderosa pine	<i>Pinus ponderosa</i>	Rare
Mountain pine	<i>Pinus uncinata</i>	Rare

The wilding tree spread from Flock Hill Station and Craigieburn Forest Park is far reaching, as can be seen in Figure 1. Wilding tree species present on the slopes of the Torlesse Range include lodgepole pine, dwarf mountain pine, Scots pine and Douglas fir. These are over 10 kilometres from the original planted sources on Flock Hill Station and Craigieburn Forest Park.

Implications of not controlling wilding tree spread

The impacts on biodiversity values are accepted and there are many existing reports that document this (refer to Harding 2001 for a list of references). The continued spread of wilding trees across Flock Hill Station and other parts of the Basin will result in a reduction of biodiversity values and transformation of iconic scenic landscapes. Recreational access will be restricted in certain areas as the proliferation of trees overgrows tracks or limits opportunities to recreate.

There are substantial areas of land administered by the Department of Conservation downwind of Flock Hill Station. Areas previously controlled on the Torlesse Range and around Castle Hill Station will be threatened by reinvasion from upwind sources, with areas previously not infected becoming under increasing threat.

There will be a reduction in the profitability of pastoral farming associated with loss of grazing opportunity and reduced water yields. This will seriously impact on the long-term viability of farming long-term which will further contribute to the continued spread of wildings as economic returns make control an unaffordable activity. Even diversified activities such as filming and ecotourism ventures on pastoral leases will be threatened, as the spread of trees closes up more and more areas to easy access.

In the absence of detailed mapping of the extent of wilding tree spread on Flock Hill Station it is inappropriate to comment on the current impact on water yield. Suffice to say that if the uncontrolled spread of wildings is allowed to continue there is very real potential for extensive areas of the Flock Hill Stream, Broken River and Winding Creek Stream catchments to become covered in closed canopy conifers. The realised effect of this on water yields will be significant. It is unlikely that this will manifest in any significant reduction in yields of the main Waimakariri River due to its size, but if wilding spread continues long-term the greater Waimakariri catchment will be exposed to increased impacts as the extent of spread expands.

From a production forestry perspective, wilding trees are usually of little commercial value. This is mainly due to the fact that the species involved are typically of limited or no value, grow on sites inappropriate for commercial harvesting and their form is poor from a marketing view point, often having large branches and tapered trunks. Forestry “by default” rarely produces any financial return significant enough to justify the associated risk of increased spread and loss of other values.

The issue of carbon credits and carbon sinks associated with wilding tree spread is still to be resolved. At this stage it looks unlikely that the retention of wilding conifers will be allowed upon consideration of the associated loss of other values, but this remains to be seen for sure. The Government will need to provide direction and guidance on this issue. In the meantime those agencies and organisations actively involved in wilding tree control should not abandon any relevant land management responsibilities and should actively encourage control operations on the assumption that there will remain a need to prevent the spread of introduced trees.

8 FUNDING OPTIONS

There are a number of different funding options that may be available to facilitate the control of wilding conifers on Flock Hill Station and surrounding land. These include a range of local and central government sources, as well as private sector. There is no doubt that a collaborative approach to funding is going to be critical to the success of any operations in the area.

DOC is the primary agency responsible for undertaking the removal of conifers for environmental benefits on public lands. It continues to invest large amounts of public funding into the lands that it administers in the Waimakariri Basin, with work to date definitely reducing some of the reinvasion potential of wilding conifers onto Flock Hill Station. This work is programmed to continue in the foreseeable future. DOC is also focussing ongoing efforts in areas downwind of Flock Hill Station. These areas are exposed to a high risk of reinvasion from the wilding spread marching across the Station. It is therefore in the Departments best interests to contribute to control efforts on the property. These efforts can only be justified in areas where there is a real risk of long-distance spread potential from exposed take-off sites.

The Department has a public responsibility to spend tax payer funds wisely and appropriately. This means that the majority of their effort needs to focus on lands directly managed and administered by the Department. However, there is justification for funding control efforts on adjacent privately owned or leasehold lands where there is a direct benefit through the creation of a buffer. This situation would be realised by a judicial funding of control in take-off areas immediately upwind of conservation land along typical spread vectors.

A funding initiative for controlling wilding trees in the high country of the South Island was established by the Government in 2004 in recognition of the Tenure Review process. This fund can be utilised for removing trees on any lands in the high country, regardless of tenure. This would be the most likely source of funding available to the Department for the control of conifers on privately managed lands. It may also be possible to partially fund through mainstream Vote Conservation funding streams or bids against the Biodiversity Fund, although the latter is unlikely to rank sufficiently high enough against other competing Departmental claims on the fund.

ECAN has an important role for ensuring protection and enhancement of distinctive characteristics of the Canterbury region, including high country environments. In doing this ECan has responsibilities to rate payers of the region to spend money in the most appropriate locations. Where control of wilding conifers is concerned, this would be best undertaken in areas with minimal chance of reinvasion from other sources outside the control area, or where there is the opportunity to augment the control effort of surrounding land managers. In this respect the Waimakariri Basin provides an ideal opportunity to extend the control work being conducted by DOC. ECan funded work on pastoral lease properties in the Waimakariri Basin would effectively work towards elimination of seed sources that threaten the conservation estate, bearing in mind that DOC is already working on eliminating the threat of reinvasion from lands it administers.

ECAN may have a number of different funding streams available to it. The Regional Pest Management Strategy has an established funding allocation for the control of wilding conifers in the Canterbury Region, which is already being used for wilding control in other parts of Canterbury. This report could be utilised to secure a portion of that funding for concentrated effort in the Waimakariri Basin. ECAN could also assist local landowners with applications for the contestable Environmental Enhancement Fund, based on the values at threat from unchecked wilding conifer spread. There may be a number of other funding sources, such as through the Community Initiatives Programme, which need to be explored.

The recently signed Memorandum of Understanding for wilding tree control in the Canterbury region between the Department of Conservation, Environment Canterbury, Federated Farmers and Land Information New Zealand may be a critical tool for securing collaborative funding.

The Biodiversity Condition and Advice Funds of Biodiversity New Zealand are a government initiative to enhance management of indigenous biodiversity outside public conservation land (www.biodiversity.govt.nz). The Biodiversity Condition Fund aims to improve and maintain the condition of areas of native vegetation, along with species and habitats, including wetlands and water bodies. Applications are invited from private landowners and community groups for projects aimed at achieving this. The Biodiversity Advice Fund supports the provision of information and advice to land managers to assist them in managing indigenous biodiversity.

There is a realistic expectation that pastoral lessees will also contribute to wilding control efforts on the land that they manager. This could be viewed as requirement of local and central government agencies before they are prepared to make a commitment to fund work on private land. Trees planted on pastoral lease properties are also a source of wilding conifers and lessees need to take responsibility for controlling some of the subsequent spread. From a legal perspective, the Land Act 1948 under which Pastoral Leases are established does not address wilding trees specifically but requires land to be farmed in a good husbandry-like manner (J. Barkla, *pers. comm*). The spread of wilding trees is in conflict with this principle.

In the case of Flock Hill Station there are a number of different parties involved, each with an obligation to contribute to wilding control efforts. The University of Canterbury as administrator of the land should take some responsibility for the lands that it retired from the lease. The lessee needs to take some responsibility for the land management practices and insure that the earning potential of their investment is not threatened by wilding tree spread. The grazing sub-lessee needs to carry out control efforts in areas that are integral to the viability of their pastoral grazing activities.

The University of Canterbury may be able to subsidise a student work scheme in association with the School of Forestry, whereby forestry students could be employed during their break to undertake wilding tree control on the University Endowment Land. Forestry students would be the primary focus as it might meet practical requirements for their study programmes as well as encourage a greater appreciation of some of the associated negative issues of forestry management. This latter component may be a worthy consideration of the School of Forestry Faculty. There is no reason why the opportunity could not be extended to other students.

Weed control is an accepted expenditure on any property. Farmers currently undertake vast amounts of gorse and broom control as a regulatory requirement under the Canterbury Regional Pest Management Strategy (RPMS). Wilding conifer control is also listed under the RPMS but is non-regulatory, with the focus being on identification and control of conifers within areas of high environmental value. Control of wilding conifers is comparatively much easier to achieve than for gorse and broom due to the visibility and predictability of the wilding problem, the relative ease of control and short seed-bank longevity. A relatively small additional investment in wilding tree control could achieve considerable gains if focussed in appropriate locations and on specific species. Similarly, the diversion of some funds from other weed control work may be acceptable in that it achieves a greater gain in terms of control while maintaining RPMS requirements for listed control plants.

Private landowners have the ability to bid for funding under the Biodiversity Condition Fund. However, such a bid needs to be based on biodiversity values. ECAN (and possibly DOC) could assist with any lessee's application to the fund.

Another source of funding that may be available, especially to Flock Hill Station, would be through the harvesting of some of the planted stands on the property. A harvesting inspection carried out by PF Olsen Limited identified that there is potential for reasonable returns from plantations at Bridge Hill, depending largely on export prices at the time. The report and accompanying letter from the company is included as Appendix 3.

It may be appropriate to approach Ensis for a contribution towards wilding conifer control costs on Flock Hill Station. As Forest Research they were the original exacerbator of the problem due to their planting efforts on the Craigieburn Research Station. They also have a continued interest in the plantation area at Bridge Hill for ongoing research of high country forestry, while the general issue of wilding tree spread and control is also of interest. The availability of an appropriate source of funding may be limited to Ensis, but they may be able to contribute in other ways. They could possibly provide some physical assistance with control efforts by providing staff to assist with operations. At the same time, research conducted by the organisation will add to the knowledge of the wilding tree issue and potentially contribute new control considerations and technology.

Given that the original source of the wilding conifer infestation on Flock Hill Station and the surrounding area came from Forest Service plantings, there is a moral obligation for central government to contribute to and support control efforts in the area. The Department of Conservation and Ensis merely inherited some responsibility through their founding organisations and as such they should not have to bear the full burden without some financial assistance from the crown.

Utility companies already undertake wilding tree control in the area for the maintenance of their networks. Transpower conducts regular tree removal operations within the immediate vicinity of their electrical supply lines, while Transit is responsible for maintaining the roadsides clear of woody weeds. These organisations may therefore be willing to contribute financially to a concerted wilding tree control operation in the area given that it will reduce their long-term commitment to ongoing

maintenance. Even if they are unwilling to do this, their ongoing work will continue to contribute to the wider efforts.

Land Information New Zealand (LINZ) is the agency responsible for managing weeds on Unallocated Crown Lands (UCL). As such it has a budget for conducting wilding tree control work. It could therefore be approached as another potential source of funding for wilding tree control in the wider Waimakariri Basin. While it may not have much land in the area that is already under infestation, it may be prepared to contribute on the grounds that a concerted control operation will prevent future spread onto lands that it administers.

A fundamental requirement of funding for any wilding conifer control effort is that it needs to be ongoing. Effective wilding control requires a long-term commitment. Removal of funding, even for a short period of time, rapidly detracts from any gains that may have been already made. It is inevitable that funding requirements will be substantial in the first ten years (depending on the amount of funding initially available), but providing this is secured and efforts continue in accordance with a predetermined plan with a realistic objective of elimination where practicable, costs will reduce dramatically thereafter. Some maintenance will still be required, but the area covered will smaller and quicker to cover, and the necessary control techniques will be cheaper and less time consuming.

A summary of potential funding agencies and the options available to them is presented in Table 3.

Table 3 – Summary of potential funding options available by organisation

Organisation	Funding Option
Central Government	Environment Budget allocation
Department of Conservation	High Country Tenure Review Funding Vote Conservation Biodiversity Fund
Environment Canterbury	Regional Pest Management Strategy Environmental Enhancement Fund Biodiversity Advice Fund Other sources
University of Canterbury	Allocation from University funds Subsidised student work scheme
Private Landowners, Occupiers and Lessees	Additional farm management allocation Diversion of existing funding Biodiversity Condition Fund Revenue from harvesting operations
Ensis	Research initiatives (including SFF) Contribution of staff time for control
Utility Companies (Transit, Transpower, Orion)	Contribution from regular network maintenance budgets
LINZ	Weed control budget allocation

9 OPERATIONAL CONTROL TECHNIQUES

The issue of wilding conifer spread and the need for control is not new to the Canterbury high country. There are a number of different techniques that have been used over the years for controlling wilding conifers, with varying degrees of success. This section outlines the main methods that have been used along with associated recommendations and limitations. It is based on the best available knowledge of current practices and may not represent a complete list. People are still trying different things or refining techniques to try and find the optimum method. At best, any effective control operation is going to involve a suite of different techniques applied to different control situations and circumstances. Regardless of what method is used, quality needs to be maintained at a high level in order to ensure effectiveness.

Grazing

Grazing is a practical control technique for some wilding conifer seedlings. In order for grazing to be effective it needs to remove all of the foliage. This depends on the palatability of the species, the age of the seedlings and stocking densities. Table 1 shows common wilding tree species according to palatability. Grazing is typically not lethal if the seedlings are more than two years old. Intensive grazing or mob stocking annually with sheep is the most effective control option, although sheep grazing at very low levels (>0.5 sheep/ha) significantly reduces wilding establishment. Cattle grazing is not as effective. It is also important to consider that there are inherent concerns with the use of grazing. These include nutrient transfer, spread of weeds and impacts on the vegetative structure.

Grazing has a significant role to play even if it is not lethal. Browsing pressure reduces the amount of cones produced on a tree. It also crops the tree, maintaining it at a shorter stature which limits its potential for throwing seed any significant distance. However, trees can rapidly outgrow browsing. If grazing is to achieve long term control the management regime needs to be consistent, with any lapse in pressure often resulting in lifting the check imposed on wilding spread. Once spread is vigorous, greater stock grazing intensity is necessary to regain any control. This situation is evident on the flats at Flock Hill Station, as is discussed in a later section.

Effective control using grazing will need use of a combination of different techniques. Mob stocking with sheep will significantly limit the spread of certain species to the extent that other control requirements are minimal. Grazing is likely to be more successful if there is associated pasture improvement. Oversowing and topdressing has a twofold effect in that it promotes increased grazing pressure on young wildings by improving their palatability, as well as improving the vigour of the underlying vegetation so that it can compete strongly with germinating seedlings. However, total control is likely to require the use of physical removal techniques to augment the grazing pressure.

Competition

As touched on briefly in the previous section, pasture improvement by oversowing and topdressing can be a simple and effective mechanism at controlling the spread of wilding conifers. It acts as a preventative measure on its own, preventing wilding

conifer seedling establishment, but in combination with grazing pressure can result in effective control.

The application of fertiliser increases competition from the existing vegetation which can result in significantly reducing the establishment of wilding seedlings, especially on grasslands. There is likely to be an associated negative impact on native plant populations though. The fertiliser also improves the palatability of any existing wilding seedlings resulting in any grazing being effective at controlling them, provided that the seedlings are less than two years old. Oversowing increases the amount of vegetation to compete with new seedling establishment by wildings.

Oversowing and topdressing is a recommended activity within a 200-400 m zone of spread-prone trees. In conjunction with grazing this can potentially eliminate the fringe spread potential of shelter belts and high country forestry plantations.

Any use of pasture improvements should follow removal of the existing wilding conifers in the target area, particularly any that are already too large to be grazed by sheep.

Burning

Burning theoretically represents the cheapest wilding tree control technique available to land managers, but it is not recommended. Burning can be very successful for controlling young trees up to 2 m tall and may also be effective on dense stands of medium sized trees. However, there are a number of limitations which reduce its practicality, the least of which is obtaining the necessary permits from rural fire authorities. Vegetation clearance by burning is a restricted activity under the Environment Canterbury Regional Plan and therefore resource consent may need to be sought, which could contribute substantially to the cost. Obtaining the acceptance of the public is a major hurdle, although this is more relevant where burning is to be undertaken on public lands. Even with all the necessary approvals, the logistics of organising a safe and effective burn makes it a major undertaking which should only be conducted by experienced people with the assistance of qualified teams.

The effectiveness of burning relates to a number of different factors. It is typically going to be more effective in dense stands where the amount of material is sufficient to promote a good hot burn. The author has observed strong recovery of small trees in sparse infestations which have been burnt as part of pasture improvement practices. As with any use of fire there is going to need to be follow up with other control techniques. Additional preparations such as crushing or spraying prior to burning may be necessary for ensuring effectiveness.

The nature of the terrain is another consideration for burning. In order to be effective the fire needs to be hot enough to remove large amounts of biomass. This will require the burn to be slow. (The alternative of burning in very dry conditions is unfavourable from a land management perspective and is unlikely to be approved for permitting.) Slow intense burns are going to be easier to achieve and more manageable where the terrain is flat or gently sloping. Where the infestation occurs on a slope it will be imperative to back burn down slope. There will be considerable requirements for fire breaking and protection in any instance.

There are also a number of environmental considerations. Fires destroy all non-target plants as well, which is another factor in favour of the need to conduct fire in dense stands of wildings where there may be limited non-target vegetation. Fire can also create an excellent seedbed for conifer reinvasion. This is more an issue where upwind seed sources remain. Little seed is likely to survive a hot fire and the rapid post-fire establishment of vigorous grasses is likely to reduce the likelihood of seedling regeneration being triggered by the fire. Oversowing and topdressing post fire will enhance the suppression of any conifer seedling regeneration.

Burning alone is not likely to be totally effective and the need for a great deal of experience and consent may make it an impractical control method. All things considered, and regardless of the density and terrain, conducting a good burn which will be successful at eliminating wilding trees will be difficult to achieve. At the very least it will eliminate a large amount of material which will then enable physical removal methods to become more practical and cost-effective. The use of fire will definitely need some follow up with other methods.

Physical Removal

There are a number of physical removal techniques that are available for effective wilding conifer control. These include ground-based removal by hand pulling, hand tools, chainsaws, scrub bars or heavy machinery, and aerial-based removal involving use of helicopters for skid or strop operations.

Ground based physical removal techniques

There are various methods of ground-based control, with different applications for according to the size and density of the target trees.

Hand pulling

Hand pulling is a quick and relatively easy way of removing seedlings up to 50 cm tall. Provided that the root is pulled completely clear of the ground and any remaining clod of earth is shaken from the roots, this technique is generally totally effective at killing conifers. It is a method that can be used by anybody, with no need for specific skill sets required other than an ability to conduct physical work, often over prolonged periods, and follow instructions.

Where hand pulling results in a tree breaking off rather than the roots being pulled out, extra attention needs to be paid to the remaining material in the ground to ensure that all green needles have been removed. Breaking is a common occurrence in areas where there is browsing pressure by stock, rabbits or hares. Where breaking is prevalent amongst hand pulled trees there may need to be consideration of using hand tools to ensure that the remaining material will not regrow.

A prolonged period of hand pulling is physically demanding and can lead to sore backs and muscle strain. It is also hard on the hands and fingers.

Hand tools

Hand tools can include loppers, secateurs, pruning saws, grubbers or axes. The author has even observed machetes being used for control, although their use has inherent safety issues which may make them a hazard in large team operations.

Hand tools generally provide the operator with the opportunity to remove trees below the surface of the ground, with the exception of secateurs and pruning saws. This essentially eliminates the risk of the tree being able to regrow from any remaining green needles.

Hand tools are best utilised for small trees up to 5 cm in diameter at the base. Pruning saws and some brands of commercial forestry lopper enable the operator to cut through significantly larger trees, but this effort needs to be weighed up against using mechanical methods. Prolonged use of hand tools or persistent efforts on trees larger than practical for the tool can result in health issues.

Ring barking

This is a useful technique that can be used on scattered mature outliers in areas where it is impractical to get a chainsaw too. It is also a technique that can be used by most people, making it an effective technique for volunteers to control larger trees than the use of hand tools alone normally enables. Any hand or mechanical tool can be utilised as long as it is sharp. Axes, slashers and chainsaws tend to be the most commonly used, with some people preferring to use sharp chisels.

Ring barking is a slow and laborious process which often has mixed results. It is therefore only practical in areas where there are few trees to be controlled. The results also take time to realise and even when effective the tree remains standing, with any viable seed in cones remaining exposed to winds and likely to spread. At least when a mature tree is on the ground, the angle for spread from intact cones is restricted.

Most people underestimate the amount of bark to be removed for this method to be effective. For this reason it tends to be more successful at killing small to medium trees, as considerable amounts of bark and outer wood need to be removed to kill large trees. Ring barking alone is therefore unreliable and is often more successful if combined with chemical application. Vigorous ring barking is recommended if it is to be used on its own.

Chainsaws

Chainsaws are a mechanical technique for felling larger trees. They make a considerably quicker job than hand tools on most trees over 5 cm in diameter at the base. The use of chainsaws represents the only practical physical control technique for trees larger than about 40 cm at the base. They can be used on trees smaller than 5 cm in diameter at the base but this needs to be weighed up against the costs relative to using hand tools on such trees.

The use of chainsaws requires a certain amount of training and experience to ensure that felling is carried out safely. They are a relatively expensive tool to run and maintain, and there is also the requirement to have a considerable amount of safety gear. Chains are easy to blunten and operators need to be conscious of keeping clear

of dirt and rocks. A considerable amount of time can be spent each day on sharpening chains, depending on the site and the competence of the operator. Having said this, proficient users can fell trees very safely and efficiently.

Chainsaws can not enable trees to be removed below the surface of the ground. This means that once a tree is felled, additional effort is required to remove any remaining branches or green needles on the stump. This in itself has inherent benefits other than ensuring the mortality of the tree. These include detection of any possible fire caused by the chainsaw (which is a very uncommon occurrence but a major consideration during the height of summer or periods of high fire danger) and enabling small seedlings growing close to the stump to be located and removed. Because of the need to remove material from a stump, chainsaw operators must also carry hand tools, preferably small axes or tomahawks. The fact that chainsaw operations require this extra step makes them slower than other mechanical methods of physical control.

Scrub Bars

Scrub bars with steel blades are another mechanical technique for felling trees, but they are limited to trees up to about 20-25 cm at the base. As they are capable of removing stumps right down to ground level they do not require the additional step associated with chainsaws and therefore are quicker. They are also more practical for removing smaller trees and seedlings where encountered.

The use of scrub bars does not require as much training as chainsaws but there is a lot to be said for experience. In the author's experience, a large number of operations using scrub bars have failed due to the inability of the operator to cut stumps low enough. It is not practical to also carry a hand tool, as in the case of chainsaw operations, so there is a reliance on removing all material with the scrub bar blade. It would appear that North Island crews have considerably more experience than their southern counterparts and are capable of producing good results. This is an important consideration when looking at hiring contract crews.

Scrub bar operations tend to be limited to more open grassland areas with minimal rock. Unlike chainsaws they can handle some rock, with blades able to continue being functional with multiple teeth missing. It is more practical to change blades than field sharpen, making them quicker to maintain than chainsaws. There is however a heavy reliance on a good support structure in place for the maintenance of blades. Operators can work on slopes but the long bar means that there are some limitations and dense scrub is impractical to work in.

The use of nylon-cord weed eaters is not a practical option for wilding conifer control due to the woody nature of the target.

Heavy machinery

The use of heavy machinery can be the most cost-effective technique for controlling very dense wildings on relatively flat or gently sloping land. Suitable machinery includes bulldozers, diggers, graders, mulchers, mowers and specialised forestry harvesting equipment such as feller/bunchers. All of these are capable of quickly clearing land.

The use of bulldozers, diggers and graders can cause considerable ground disturbance which can encourage wilding trees or other weeds to reinvade the site. This creates problems in areas which are not likely to be cultivated following control. Harvesting machinery is likely to be very useful in stands of mature trees where the lower branches are typically clear of any green material.

Tractor-driven mulchers are becoming increasingly utilised. They can be quite successful in controlling trees up to 3-4 metres tall. It is unlikely that a single pass will be successful at removing all green material from stumps, with a second pass dramatically increasing effectiveness. It is still likely that some regrowth may occur and so the area should be reworked, either by further mulching or spraying, after the slash has totally browned off. Rework should not be left any later than two years as any remaining mature live material will be able to produce seed very rapidly. The disadvantages of mulching are its relative non-specificity, with non-target vegetation also being destroyed, and the fact that seed is not destroyed.

Aerial based physical removal techniques

Due to the fact that wilding trees often grow in remote or difficult to access locations it is often cost-effective to use helicopters for transporting ground crews to the work site. It is also safer as the effort required to walk into sites that can not be driven to is energy sapping on personnel, especially where this walk is uphill as is often the case. This technique is referred to as helicopter ferry and is used extensively in mountainous areas but also has application in fragile environments where wheeled vehicles are not practical. Once ground crews reach their work area they use any combination of the ground based physical removal techniques.

The following two techniques are variations of helicopter access. They merely involve transportation of individuals rather than groups and are capable of putting personnel very close to target trees.

Skid hopping

This is a technique whereby operators are dropped off at remote trees without the need for the helicopter to physically land. It involves the machine getting as close to the tree as is safely and practically possible and then the operator climbs out along the skid, removing their equipment from an under-belly basket. Such operations require an observer and coordinator alongside the pilot in the machine to ensure that operations are conducted smoothly, safely and efficiently. Personnel involved in such operations need to be sufficiently trained and competent around helicopters, with a good head for heights. Often the operator is many feet above the ground when they first exit the aircraft.

Skid hopping is a very efficient technique for tackling isolated or scattered trees in remote country. The aerial platform allows large areas of ground to be covered very quickly, with target trees typically being very visible from the air. The technique can also be used to put larger crews on the ground in remote and difficult to access locations, in such instances performing more of a traditional helicopter ferry role. The machine leaves the personnel at this location and can continue with skid hopping elsewhere with a small number of operators or returns to its base.

There are a number of important considerations when planning to undertake skid hopping operations. There are practical limitations to where they can safely proceed and the pilot is the best person to ascertain this. It is important that conditions are not too windy or that the terrain is not too steep. It is also very important that all staff involved, including pilots, are competent and preferably experienced for the work to be undertaken. The choice of helicopter is of paramount importance. Many managers believe that use of small helicopters such as Robinsons is the most cost-efficient. However, the author is a strong advocate of the need to use multi-bladed turbine driven helicopters for all skid hopping operations.

The reasons for using multi-bladed turbine driven helicopters include:

- an unarguably steadier platform due to greater lateral stability compared to smaller two-bladed aircraft
- greater power and capacity for working in mountainous environments compared to piston driven aircraft
- the ability to carry more people, which easily offsets any perceived loss of cost-effectiveness compared to smaller cheaper aircraft
- capable of carrying an onboard observer at all times to assist with coordination and provide first aid assistance in the event of an accident to an operator on the ground
- ability to use a skid-mounted basket for holding all operational equipment.

The minimum requirement would be a Hughes 500. Smaller helicopters such as Robinsons could be safely used at lower altitudes on terrain where it will always be possible to put both skids on the ground for landing and passenger offload. Jet Rangers also require the ability to be able to put both skids on the ground due to their two-bladed system. Larger aircraft such as Squirrels and Iroquois are useful for ferry but their skid configurations and blade dimensions make them unsuitable for skid hop work in most hill and high country terrain. The cost can also be prohibitive.

The most suitable helicopter used in operations involving the author was a Hughes 520N, which does not have a tail-rotor. Use of this machine therefore eliminates the hazard of tail-rotor strike from skid hop operations, which enables chainsaw operators to be deployed into tighter confined spaces than would otherwise be practical.

Strop or human sling

This is a highly specialised technique which moves single operators around while attached to a strop underneath the helicopter. It is used for accessing trees in areas where skid hopping would be impractical or unsafe. This includes trees growing in very steep terrain, in bluffs, or where the surrounding vegetation is tall.

Helicopter operations involving this technique require considerable amounts of specialised safety gear, including full body harnesses, rated load bearing ropes and hardware, and helicopter belly ropes. In addition to experienced and competent pilots and chainsaw operators, human sling operations need an additional safety person on board the machine at all times to observe the sling and be prepared to undertake certain actions in the event of incident. The highly specialised nature of these operations mean that typically only two or three chainsaw operators are used for any particular operation. Costs and practicalities preclude the feasibility of using more staff than this.

Human sling operations may seem expensive but this is a false assumption. The fact that the helicopter is always distant from the ground makes the operation considerably safer by eliminating the inherent risk associated with operators getting in and out of machines hovering near the ground. They are also considerably quicker as the pilot does not need to find a suitable location on the ground to accommodate the machine while operators embark and disembark. The fact that operators can be put right at their target trees, often being lowered through the surrounding canopy, also means that removal is more efficient. These factors of safety and efficiency combine to offset any perception of higher cost. There is a strong reliance on good communications between the pilot, safety person and sling operator to ensure that all goes smoothly though.

Trees of any size can be targeted by such operations, from seedlings to mature trees. It is access that dictates the need to use this technique. Conditions need to be fairly calm for it to be practical though.

Chemical Application

The use of chemicals may be a useful control technique where wildings are dense and extensive. It is also useful for areas where it is too dangerous or difficult to use other techniques, or the felling is deemed inappropriate due to problems associated with fallen material and light wells.

Chemicals definitely provide a relatively cheap form of control, although effectiveness is highly variable dependant on a number of factors including the size of the trees and timing of spray operations. At the very least, application of chemical will generally halt the immediate threat of spread by interfering with the production of seed, at least in the interim.

The problems with using any chemicals are the potential non-target impacts and the fact that it takes a considerable period of time after application to determine effectiveness of control.

This section avoids providing a list of recommended chemicals. This is due to the high variability of chemicals used for the control of wilding trees, depending on characteristics of site, species and size. Numerous chemicals have been trialled over the years and references can be obtained from a report prepared by Peter Raal (2005). Before any use of chemical is considered there needs to be an options analysis and effectiveness trial to determine what chemical would be most suited for the job.

Stem poisoning

Involves killing trees standing which allows their breakdown to be considerably more gradual. This may provide ecological benefits such as limiting the damage to existing vegetation, allowing shade-tolerant native trees to regenerate and providing perching or nesting material for birds. It may also be an important technique for areas on steep coastal or lakeside areas to prevent a threat of submerged material to watercraft. The issue of standing dead trees poses an obvious aesthetic issue, while the potential implication of the hazard of falling debris is still to be fully appreciated.

Poisoning involves a number of different techniques. These involve ring barking, frilling or stem boring the base of trees, with chemical applied to the damaged stem. The tools typically used include axes, chainsaws and powered drills. The incisions or holes need to be sufficiently deep to penetrate to the conductive material, which combined with the amount of chemical used tends to be the limiting factor of effectiveness for this technique. The amount of chemical applied depends on the size of the tree, susceptibility of the species and the toxicity of the chemical used. Ring barking tends to be less reliable than frilling and stem boring.

This technique is very labour intensive and has inherent safety issues around the use and storage of toxic substances. There are also problems with obtaining access to target trees due to dense vegetation and steep or rocky terrain.

A number of different poisoning techniques involving the application of chemicals in a pellet or projectile form have been developed over the year. These have involved the use of propellants to inject the chemical into the stem of a tree. There have been mixed results. A new technique involving the application of chemicals to the bark of trees is currently under investigation. This can be applied very simply using a backpack and applicator nozzle such as a drench gun. This technique may be useful for trees in very difficult terrain, where operators can use abseiling gear or be under-slung from helicopters for gaining access.

Foliar coverage

Chemicals can be applied by a number of different means, including back pack sprayers, vehicle mounted pumps or aerially. Full foliar coverage is the critical issue for achieving tree mortality, especially for lodgepole pine. Timing is also important. The more active the growing conditions the better the results. It may take up to two years to see the final results of foliar spraying. Some trees are also notoriously difficult to kill by spraying, including lodgepole pine and Corsican pine.

A significant number of different chemicals have been tried over the years with mixed results. Some have significant and severe non-target effects. The biggest issue with effectiveness tends to be the ability to penetrate the waxy cuticle of pine needles. An adjuvant needs to be added.

Helicopter boom spraying provides consistently poor results. This is both in terms of effectiveness and non-specificity. However, if the objective is to halt the spread of trees and multiple operations are acceptable, it provides considerably better results with repeated applications. Spot spraying, gun application or ground-based boom spraying provides good results with a single application provided that total foliar coverage is achieved.

Stump pasting

This involves the application of a chemical to the cut stump of a tree. It is very useful where it is not possible to confidently remove all of the green material from stumps due to the presence of rock or thick vegetation.

The ease of use and danger of spillage are problems associated with this technique. Gel based chemicals are the best suited to this technique.

10 OPERATIONAL CONTROL MECHANISMS

This section focuses on operations involving personnel. Stocking is a significant mechanism and possibly the cheapest in that it constitutes part of normal farming practices. However, it has been given sufficient consideration in the previous section and is therefore not included here.

Volunteers

Volunteers can be the cheapest option for operations involving personnel. However there are a number of limitations to their use. These include:-

- restricted work hours (typically only available in the weekends)
- limited to use of hand tools because of health and safety requirements
- frequently changing personnel
- inability to hold accountable for quality and productivity
- significant requirement for instruction and supervision.

There is also an often considerable cost involved in the logistics and coordination of volunteers. It can take significant amounts of time to make all the necessary arrangements for organising volunteers. There is also potentially substantial transportation, accommodation and catering costs, depending on the location and duration of the volunteer effort.

The limitations should not be seen as a deterrent for the use of volunteers. Volunteers are a very good source of workers. They are often highly motivated for the end objective and show great energy and enthusiasm for the task. Involving them in high profile locations adds to the general awareness of the problem. Many volunteers also represent environmental NGO's, such as Forest and Bird, which represent powerful lobbyists. These are significant allies in achieving recognition of wilding tree problems in the high country and are in a position to provide strong support for greater government funding for control efforts. The accumulated costs of using volunteers is still usually significantly less than the cost of running similar operations involving staff or contractors.

An important consideration for the use of volunteers is that their efforts need to be concentrated in areas where they can see that they can achieve a realistic objective. They are therefore of most use in areas of sparse or new infestation, or working back from the furthest extent of an area of spread, provided that the densities of the trees are not too great. The trees also need to be of a size manageable by a hand tool dominated workforce. It is also very important to support the efforts of volunteers by conducting other control efforts in source trees. In this way volunteers can see that their efforts will not need to be a major ongoing commitment.

Professional Contractors

Typically contractors represent the most expensive mechanism of control due to the specialised training and equipment that they need for carrying out their activities. Contractors can utilise a range of control techniques, from ground based hand tool operations to chainsaw work, heavy machinery and spraying. They may be teams of trained removal staff or operators of specialist equipment used in control operations, such as mulchers or helicopters.

In addition to the expense, there may also be issues in terms of availability of contractors. They operate in a competitive work environment, which provides some benefits in terms of pricing structures, but contractual obligations to other jobs may mean that they are only available at certain times. Those organisations employing contractors need to be aware of this and accept a need for some flexibility with the timing of operations. Having said this, contractors will endeavour to make every effort to secure and satisfactorily complete operational contracts, as reputation has a major influence on employability.

Some of the benefits of using professional contractors includes:-

- consistent hours and personnel
- less need for instruction and supervision as contractual obligations are explicit regarding quality requirements
- workforce is accountable due to contractual requirements and is therefore reliable
- capable of using a wide range of control techniques
- have legislative responsibilities under the Health and Safety in Employment Act for meeting certain standards of safety, training and equipment for the type of work involved with.

Another consideration for the use of contractors is the conditions under which they can work. They have a reasonable expectation to be able to carry out their work and where the weather hinders this they may need to pull out to attend other jobs in order to keep staff busy. This needs to be recognised. Some lost time is likely to be inevitable when working in the high country.

Staff – farm and organisational

The ability of staff to be effective mechanisms of control must not be overlooked. They are typically the ones that are most familiar with the land management issues and have some inherent ownership of these issues.

In the case of farm staff, they are the ones in most regular contact with the land. They are capable of making very valuable contributions to control efforts by identifying areas where wilding spread occurs and by controlling isolated trees when they encounter them. Farm staff should carry some form of control technology with them at all times, whether it be hand tools, chainsaws or chemical, so that they can carry out ad hoc control as the opportunity arises. This may be as simple as hand pulling seedlings or small trees. Removal of larger trees or clumps of regeneration could be included as part of general work programmes as time permits.

There are some limitations associated with the use of farm staff. They have other responsibilities which often result in little time being available for controlling wilding trees. Typically they have not got the necessary training or experience to undertake the safe control of larger trees. They may also not have a clear understanding of operational requirements for achieving effective control. Too often the efforts of farmers have been thwarted by a lack of appreciation of the “no green needles” concept. This results in regrowth and a prevailing attitude that wilding tree control is a waste of time and effort. In this respect there needs to be greater collaboration

between ECAN, DOC and land managers regarding the provision of advice based on experience, with an associated willingness on the part of land managers to adhere to that advice. This information flow needs to be both ways as farmers are often in a position to provide information on alternative techniques that work for them which would add to the collective knowledge.

Department of Conservation and Environment Canterbury staff are required to have all the necessary training and equipment necessary for conducting certain control operations. They are also capable of putting together teams of sufficient size and capability for undertaking concentrated control operations. However, their work programmes are diverse and typically need to focus efforts on lands administered by their organisations. The amount of time that can be spent on wilding control operations needs to be offset against competing demands, which often results in limited time being available.

In the case of DOC staff, they tend to undertake work in small areas with easy access or over larger areas where specialist aerial control is required. For larger areas or denser infestations there tends to be a reliance on contractors.

ECAN has coordinated concentrated control efforts using teams of its staff in other locations in Canterbury. The development of specialist wilding control teams and the encouragement of staff to participate in work-days on wilding control projects would be a beneficial organisational initiative. This may be an option for conducting control work in parts of the Waimakariri Basin.

It may be possible to organise control operations that involve staff from DOC, ECAN and farms. Such workdays would provide an ideal opportunity to collaborate on ideas and techniques, as well as foster good working relationships between all of the parties.

The need for good supervision

Regardless of the type of operation or the mechanism of control, it is essential to have good supervision to ensure a high standard of quality control. As mentioned above, enforcing quality control considerations is considerably easier when dealing with contractors as they have contractual obligations. However, volunteers also want to do a good job and will generally make every effort to comply provided that they receive timely and appropriate advice.

11 COSTS

The control of wilding conifers can become costly and needs a long-term commitment. However, the amount of money and time required can be minimised by thorough operations conducted at regular intervals prior to seed development (Woods 2004).

The costs of removal differ according to the size of target trees, their density, terrain and the ease of access. Removal of mature trees is more expensive than removal of younger trees due to the techniques involved and the time required. Costs are lowest for seedlings which can be easily hand-pulled or cut out using hand tools. Mature trees also have an associated maintenance cost as it is inevitable that they have regenerated. Alternatively, young trees occur at potentially very high densities in fringe spread situations which has an associated increase in costs. Need to ensure that control is timed prior to coning of the next generation so as to minimise costs.

Costs are extremely hard to estimate due to the high amount of variability of both within and between control sites. The figures used in Table 4 are conservative estimates based on control operations conducted over recent years. They represent a range to reflect the variability of site conditions. Note that those operations involving helicopter ferry are likely to be at the higher end of the range of costs.

Depending on the nature of the infestation at the initial control stage, the costs of maintenance are also highly variable. If the trees were already coning then there is likely to be high rates of regeneration. In some cases where the initial infestation was a dense stand, the resulting regeneration may be at extreme densities, with associated high costs for the first maintenance operation. However, the costs of subsequent maintenance operations will be progressively decrease. Where maintenance involves areas that had limited or no natural regeneration occurring at the time of initial control, associated costs are likely to be very low.

No attempt has been made here to attribute costs for farm management practices of burning, grazing, oversowing and topdressing, or for the use of farm staff in removal operations. These are best known by farm managers. This is a section which should be added to the table after consultation with farmers.

There is no guarantee that the actual costs will be as reported here. A more accurate estimate can only be achieved after some work has been conducted on a block to determine the impact of the site variables. Better mapping of the work site with break-down according to density will also be important for refining costs.

Table 4 – Average costs associated with different wilding tree control operations, based on recent operations in the South Island high country

Operation	Characteristics	Average cost per hectare	Comments
Volunteers utilising hand tools with some chainsaw support	Typically scattered spread at low-moderate densities	\$2	Covers cost of transport, coordination and supervision
Contractors using hand tools	Small trees at high to extreme density	\$2000-3500	Likely cost of maintenance operations
	Moderate to high density	\$250-750	
	Low densities	\$10-100	
Contractors using predominantly scrub-bars with some supporting chainsaws for larger trees	Small trees at high to extreme densities	\$500-1600	Excludes likely establishment cost of contract crew
	Mixed age sparse density areas	\$100	
Contractors using chainsaws	Dense mature stands	\$5000-10,000	Depends on species and access
	Dense fringe spread	\$1000-2000	Regeneration
	Frequent outliers of moderate to high density	\$150-300	Associated costs likely to be higher if operations require helicopter ferry to access work site
	Occasional low to moderate density outliers	\$15-30	
Helicopter skid-hopping operation	For very low to moderate density	\$2-30	Based on use of a Hughes 500
Helicopter human sling operations	Low density in difficult terrain	\$10	Operation involving specialist contractors and a Hughes 500D
	Moderate density in tall vegetation	\$200-500	
Heavy machinery for controlling dense stands of small to medium trees	Mulcher using two sweeps	\$300-500	Have associated transport costs
	Digger and bulldozer	\$400	Based on Molesworth costs
Aerial spraying	Helicopter boom application	\$500-1000	Based on application rate of \$250/ha + chemical
	Spot application	<\$500	Depends on density
Stump application	Can only be used in support of felling operations	\$100-200	Additional cost per hectare Depends on density

12 PRIORITIES FOR CONTROL

Obviously it would be ideal to control all parts of a wilding tree infestation at once but this is rarely practical given the scale of the problem, especially within the Basin. Considerations for prioritising wilding conifer control operations on limited budgets are numerous. However, total removal should always be the ultimate objective unless there is to be an obligation to ongoing control in perpetuity. Either way, a long-term commitment is necessary.

Total removal will be the more costly option in the short to medium term, but if carried out effectively it can result in no ongoing costs in the long-term as all potential sources for reinfestation are removed. The time required and total cost for complete control is determined by the amount of effort put in. It would be important to remove all trees prior to coning in subsequent maintenance operations.

Factors to take into account for prioritising control include:

- species and sites involved – the most spread prone trees need to be removed from significant take-off sites as a top priority;
- size and density of trees – trees at low densities at the extent of the spread should be a higher priority than dense stands of large trees, with efforts progressively removing larger trees back towards the source;
- accessibility – the relative costs of helicopter versus ground-based access favours placing a higher priority on remote areas before their density makes access too expensive for efficient control;
- appropriate techniques and mechanisms for removal – utilising the best tools and the most suited agent for the job will minimise costs improve efficiency
- potential risk to lands downwind – the realistic likelihood of spread onto and the vulnerability of downwind sites influences what seed sources to control
- other control operations – work is best targeted in areas where it augments other efforts.

Each of these considerations needs to be taken into account relative to each other.

In the case of Flock Hill Station, the ultimate downwind recipient of the current generations of seed is the Korowai/Torlesse Conservation Park. The significant amount of work already carried out by DOC on this piece of public land is testimony to the vulnerability of the area to invasion. For the purpose of this report I have therefore focussed on spread potential as a major determinant of priority on the assumption that downwind vulnerability is certain.

Of the three original planted sources of wilding trees, Helicopter Hill is the highest and is most likely to produce long-distance spread in the order of ten kilometres. Spread from this area under the prevailing north-westerly winds threatens considerable areas on the western and southern slopes of Broken Hill. Helicopter Hill is now being targeted for control by DOC, with trees around the summit having been felled and sprayed during the 2006/07 operational season. This work is scheduled to continue.

Although Bridge Hill is lower, seed from it is capable of dispersing down Flock Hill Stream, with subsequent generations threatening the Torlesse Range. While DOC have already controlled most of the trees posing immediate threat of long-distance

spread from the Upper Hut Creek Catchment, a significant source remains in spread-prone areas on the south side.

While the trees around the farm buildings only pose a threat to a relatively small area, it is important that work is still undertaken here to restrict the potential for reinvasion of controlled areas.

Of greatest concern for long-term threat is the natural regeneration that has occurred as a result of these plantings. Trees continue to spread further downwind with each generation. Those areas of regeneration occurring on exposed “take-off” sites which immediately threaten vulnerable land areas downwind are of greatest priority.

Control Options

There are five distinct options available for the control of wilding trees. These are listed below in decreasing order of preference for achieving the ultimate goal of environmental protection:

- 1) Total control – everything is removed in a single operation
- 2) Progressive control – removes trees over time through multiple operations
- 3) Site specific control – targets complete removal of all trees from certain areas
- 4) Containment – preventing further spread by controlling the edge of an infestation only
- 5) No control – obviously does not achieve any environmental protection

Budgetary limitations mean that it is not often possible to pursue total control in a single operation. Progressive control should achieve the same result but requires a longer period of time. The no control option should be discounted unless the implications for environmental values are acceptable

Containment can be a practical and affordable control option provided that distant spread is not possible. This would require just a narrow strip around the infestation to be controlled at intervals.

Table 6 & 7 identify priorities and options for control for each of the control blocks identified in section 14 – Operational Control Blocks.

Frequency of Control Operations

The frequency of control depends on species composition and the proximity to a seed source. The age of the trees at the time of initial control is also a contributing factor as mature trees are likely to have already regenerated. This potential to regenerate is likely to continue even after felling until such time as the remaining cones on the trees have broken down. This may take a significant period of time for those species with persistent cones such as lodgepole pine and radiata pine.

As lodgepole pine is the main wilding tree species on the property, any frequency of maintenance operations should be based on its spread characteristics. As a general rule, maintenance operations should be conducted every 3-4 years in areas that contained mature trees at the time of initial control. This is based on the fact that small trees and seedlings were inevitably missed and that these will be capable of

producing seed at eight years of age (Table 1). Control blocks where removal was targeted at trees above a certain height only should be maintained at three year intervals to compensate for the potentially higher age of the remaining wildings.

Areas where there was sparse spread and no mature trees present at the time of initial control may be left for 4-5 years before conducting maintenance control operations. However, it would be advisable to conduct visual inspections of these sites at more regular three yearly intervals so as to detect and initiate control of any trees nearing maturity.

Inspection of areas previously clear of wilding trees needs to be conducted at a maximum frequency of five years, provided that any control deemed necessary can be conducted immediately.

As long as the seed source remains there is likely to be a need for maintenance operations in perpetuity. The only circumstances where maintenance needs to be conducted more frequently than three yearly may be in those areas where volunteers are used for control. This is so that easy control can be achieved using hand tools while the trees are still very small. Otherwise it would be pointless returning to a site more often than is necessary as the resources would be better utilised elsewhere, allowing trees in controlled sites to become more visible in the inter-operational period.

Wilding tree control operations involving aerial spraying are unlikely to be totally effective with a single operation. It is very important to carry out further spraying operations in subsequent seasons, particularly where the targeted trees are greater than 1.5 meters tall. The frequency of return operations should be at 1-2 yearly intervals to prevent any significant recovery of the target trees following the previous control. It may be necessary to conduct three or four separate operations before the trees are effectively controlled, depending on the size and density of the trees.

13 OPERATIONAL CONSIDERATIONS

The appearance of highly valued limestone landforms in the Broken River area are easily spoiled by tracking. Vehicle impacts in this area need to be minimised, with ground based sweeps involving removal operators being favoured over any mechanical methods of control. It is therefore very important to remain vigilant in this area to ensure that control is conducted before tree densities get too high. Additional tracking should be avoided as far as practical with existing tracks utilised.

Some areas of the property contain high conservation values that are vulnerable to grazing pressure. While the protection of biodiversity through wilding tree control needs to be balanced against pastoral farming considerations, it is important to encourage minimum impact in these areas. The use of grazing as a control mechanism should be avoided in these areas, with efforts favouring use of low impact methods. Vigilance should be maintained in these areas to ensure that trees are removed while they are still small and before the infestation is able to expand.

The presence of honeydew in the beech forest supports a significant wasp population. These can pose a major problem for wilding tree control operations during summer and need to be identified as a site specific work hazard.

There is ample accommodation available for contractors, with lodges at Flock Hill Station, local ski fields and within Craigieburn Forest Park. Alternative accommodation may be sourced in Springfield or Arthurs Pass although these will require longer travel times. An arrangement may be possible with Flock Hill Station where they contribute accommodation costs as part of their assistance with control operations on the property.

While there are obvious financial benefits of harvesting the plantations below Bridge Hill, there are also implications for the continued spread of trees and other weeds. Some of the species involved are not likely to be contributing to the wilding problem, with Ponderosa pine and Corscian pine unlikely to spread much under the prevailing environmental conditions. Their removal would potentially just be creating a void for other wildings to invade. As with any removal of mature trees, some post harvest consideration will be necessary for controlling any reinfestation, particularly by wilding lodgepole pine. Douglas fir is another species that is highly likely to regenerate in areas where it was removed.

Any financial return realised by Flock Hill Station from harvesting is unlikely to offset all of the costs associated with its wider wilding tree control commitments. However, where plantation trees are identified for removal it is beneficial to harvest even if the returns only just cover the costs (i.e. cost neutral) as it at least removes all of the slash from the site making it easier to carry out maintenance operations.

The recommendation to promote oversowing and topdressing as methods of controlling wilding conifers is likely to receive some opposition. However, this technique is going to be necessary if the effective elimination of trees is to be achieved, especially considering the ongoing farming focus of affected areas.

14 OPERATIONAL CONTROL BLOCKS

Operational control blocks have been defined for key areas of wilding spread on Flock Hill Station. No effort has been made to include operational areas for DOC as they are already working within their organisational planning system and appear to be working well towards the common goal of controlling wilding pines within the Waimakariri Basin. Similarly there are no specific control blocks for other pastoral lease properties in the area as they were not investigated as thoroughly as Flock Hill Station.

The following sections describe the recommended operational control blocks, along with suggested control techniques and approximate costs for first stage control. Note that this is an important consideration – the cost for subsequent maintenance control operations has not been factored in here due to the inherent difficulties in forecasting prices into the future. This can only be achieved with any modicum of accuracy closer to the operational period. However, I have included in each section a suggested frequency for maintenance returns and predicted number of such operations.

Information included in each description pertains to the observed wilding situation, area covered, terrain, access and general control considerations. There is also a suggested agency and mechanism for carrying out the control operation within the block, along with justification. Where blocks have been broken into multiple parts each part is dealt with separately, although any operation occurring within part of the block could be continued in other parts as finance and resources permitted. An overview map of all the control blocks is included as Appendix A – Flock Hill Station Control Blocks. Letters at the start of control block names correspond to the labels on Appendix A.

Wilding tree density is estimated based on the categories set out in Table 5.

Table 5 – Density classes based on number of stems per hectare

Density Classes	Abbreviation	Stems per hectare
Very low	VL	<1
Low	L	1-10
Moderate	M	10-100
High	H	100-1000
Very high	VH	1000-10,000
Extremely dense	E	>10,000

It is important to reiterate at this point that the densities of regenerating wildings involved in maintenance control operations depends on the stage of the infestation at the time of initial control. Densities of trees may far exceed the original infestation but this is offset by the small size of the trees. Subsequent maintenance operations will involve progressively less trees provided that they are conducted prior to maturity and the threat of reinvasion from other areas is low or eliminated.

A – Bridge Hill Control Block 180 hectares (Figure 5)

Located on the western extremity of the property on the lower slopes of the Craigieburn Range. Situated between Craigieburn Forest Park to the west and SH73 to the east, it extends from the Craigieburn Shelter road to the Western Block.

It covers moderately steep slopes and adjoining flats below point 1095 and to the east and south of Bridge Hill. The area is very visible from the state highway and has high public use as it includes the access road to the Broken River Ski Area, Environmental Education Centre and Bridge Hill batches. This high visibility is an operational consideration.

This represents a key area for the control of wilding spread, with the eventual removal of all trees necessary to eliminate the threat to adjacent lands as well as those further downwind of the prevailing conditions.

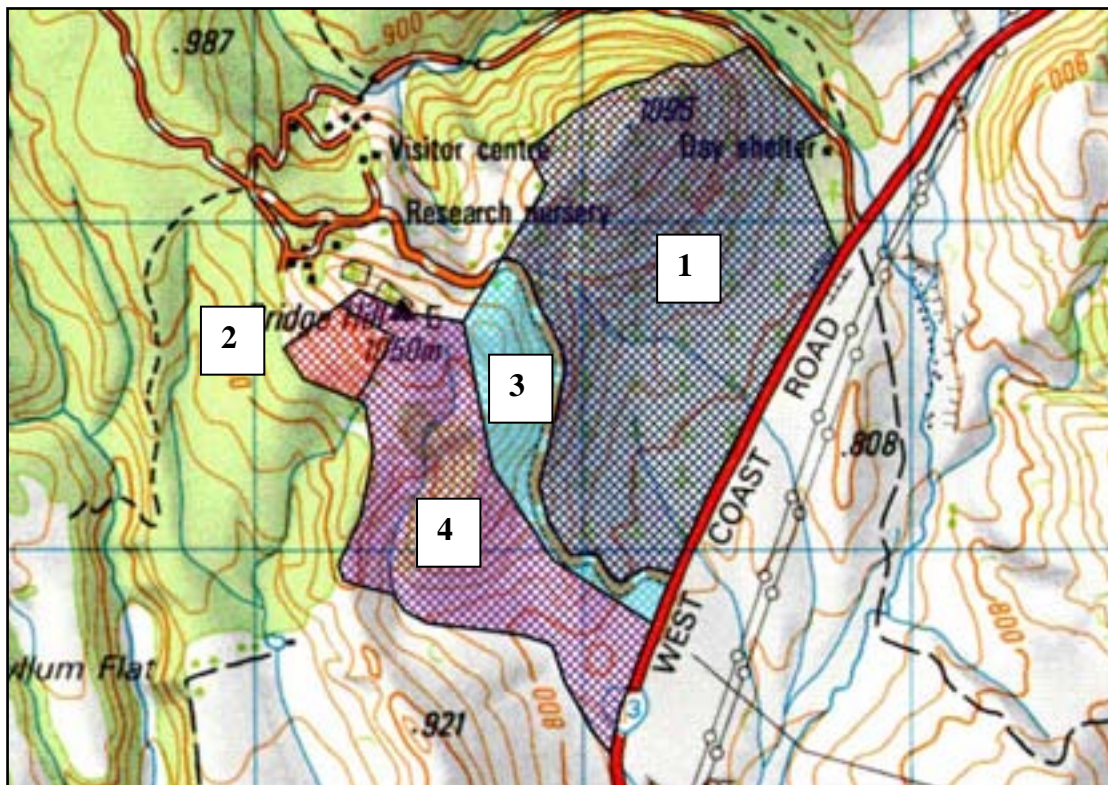


Figure 5 – Bridge Hill Control Block showing component control blocks as 1 (Exotic Plantings), 2 (Summit Stand), 3 (Ski Field Access) and 4 (South Face)

A1 – Exotic Plantings Control Block (104 hectares) [Priority 26=]

This area contains experimental and production plantings of exotic trees on the flats and slopes west of the highway. Indigenous shrublands are strongly regenerating above and alongside the plantations, with grasslands dominating the lower slopes. Large areas of wetland vegetation occupy seepage areas on the lower slopes of Bridge Hill.

Vigorous wilding tree spread surrounds the plantings on most sides and they are likely to be the main seed source for the extensive wilding tree spread across the Pylon Flats

Block. Densities typically range from moderate to high, although some areas on the flats are largely clear of wilding spread.

The original plantings provide a potential source of revenue for the property. Not all of these are spreading, but there is significant infilling with lodgepole pine. From a conservation perspective, the existing plantings compromise the roadside scenery, prevent the restoration of native shrublands and forests, and threaten adjoining areas by providing a seed source for further wilding tree establishment. Due to the location, the immediate threat of the latter is likely to be limited to the immediate area as long-distance spread is unlikely to occur.

While this block is not of immediate concern for wilding spread, its retention will jeopardise any efforts to control wildings on the adjacent Pylon Flats Block as well as compromise the ability of DOC to manage the Craigieburn Forest Park. Any spread emanating from the plantations should be actively controlled due to the associated threat to adjacent areas. It is also unlikely to be of any commercial value.

Refer to Appendix C for the harvesting report prepared by PF Olsen Limited in respect of this area. The plantation area also still has considerable value for ongoing research into high country forestry, although this consideration should not be favoured above any potential for harvesting or the long-term control of wilding tree spread (N. Ledgard, *pers. comm.*).

Access is very easy. Any control efforts should be the responsibility of Flock Hill Station. Harvesting of the plantation blocks is recommended to remove a seed source and provide adequate funding to undertake wilding control. Control of wildings could be undertaken by farm staff or contractors using a mix of chainsaws, hand tools and scrub bars. The associated cost will depend on how much of the area is harvested. For the purpose of calculating costs for this report, it is assumed that half of the area will require control.

A2 – Summit Stand Control Block (6 hectares) [Priority 4]

Located on the upper slopes south of the Bridge Hill summit this stand of very high density contains the most mature trees at the western extent of the property. It has essentially been contained by previous control efforts in the vicinity. Attempts by ECan to control trees within the block using aerial spraying failed due to a lack of follow-up control, with the trees targeted having recovered.

The trees in this block are located on an exposed “take-off” site that poses a considerable threat to extensive areas of the Flock Hill Stream and Broken River Catchments downwind. Its location at the extent of the spread also jeopardises any other control work conducted downwind.

While this block is relatively easily accessed by ground crews, it is recommended that control be conducted by aerial spraying due to the considerably cheaper associated cost. The requirement for resource consent to apply chemicals aerially needs to be investigated. This work should be coordinated by ECan in support of its earlier efforts in the area.

A3 – Ski Field Access Control Block (20 hectares) [Priority 9]

That area bounded by the Broken River Ski Field access road and a fence to the south which comes down from the top of Bridge Hill. It contains areas of very high density mature trees immediately adjacent to the road, with considerable numbers of young trees populating areas of regenerating shrubland near the summit. Further mature trees are growing on exposed “take-off” sites near the summit.

ECan and DOC have both been involved with wilding tree control operations in this area in the past. It is recommended that further collaborative control be conducted on this block as a high priority due to the threat posed to downwind areas and the proximity to the western extent of the spread. DOC should concentrate its efforts on the immediate area of the summit where spread is likely to have originated from planted trees on the adjacent public land. ECan efforts should target areas adjacent to the road and on the front faces of Bridge Hill.

Operations should be ground based involving a mix of staff and contractors utilising both chainsaws and hand tools. The terrain is sloping and access is very easy. Appropriate precautions will have to be taken when operating around the road.

A4 – South Face Control Block (50 hectares) [Priority 13=]

Located between the Ski Field Access and Western Control Blocks, this site contains regenerating trees of moderate to high density, with pockets of very high density. The area has been the focus of numerous volunteer control efforts in the past but the size of the trees and their density is now beyond the reasonable capacity of volunteers.

Although the area does not pose a significant threat to adjacent areas at this time it should be targeted as a high priority so as to protect previous control efforts. This should be done in the near future as some of the trees are nearing coning age.

The use of ground-based contractors using a mix of chainsaws and hand tools is recommended for control, with ECan the coordinator due to its previous efforts in the area. The terrain is sloping and the existing vegetation ranges from shrubland to grassland. Access is easy. The operation is likely to be relatively quick and provides a good fallback option for contractors on days of inclement weather during operations on remoter parts of the property.

B – Western Control Block 326 hectares (Figure 6) [**Priority 13=**]

That area on the western extremity of the property bordered by SH73 to the east, Craigeburn Forest Park to the west and the Castle Hill pastoral lease to the south. It extends from the Bridge Hill Control Block to Cave Stream Scenic Reserve.

Due to previous control efforts in this area the wildings present are generally young trees meaning that hand tools will be the cheapest and most effective method of control. The density of young regeneration on the river terraces adjacent to Castle Hill Station in the south of the block is quite high.

Access to the block is easy with a number of vehicle entry points. The terrain is gentle. As parts of the block are immediately adjacent to SH73, appropriate precautions will have to be taken to ensure safety and prevent slash ending up on the road.

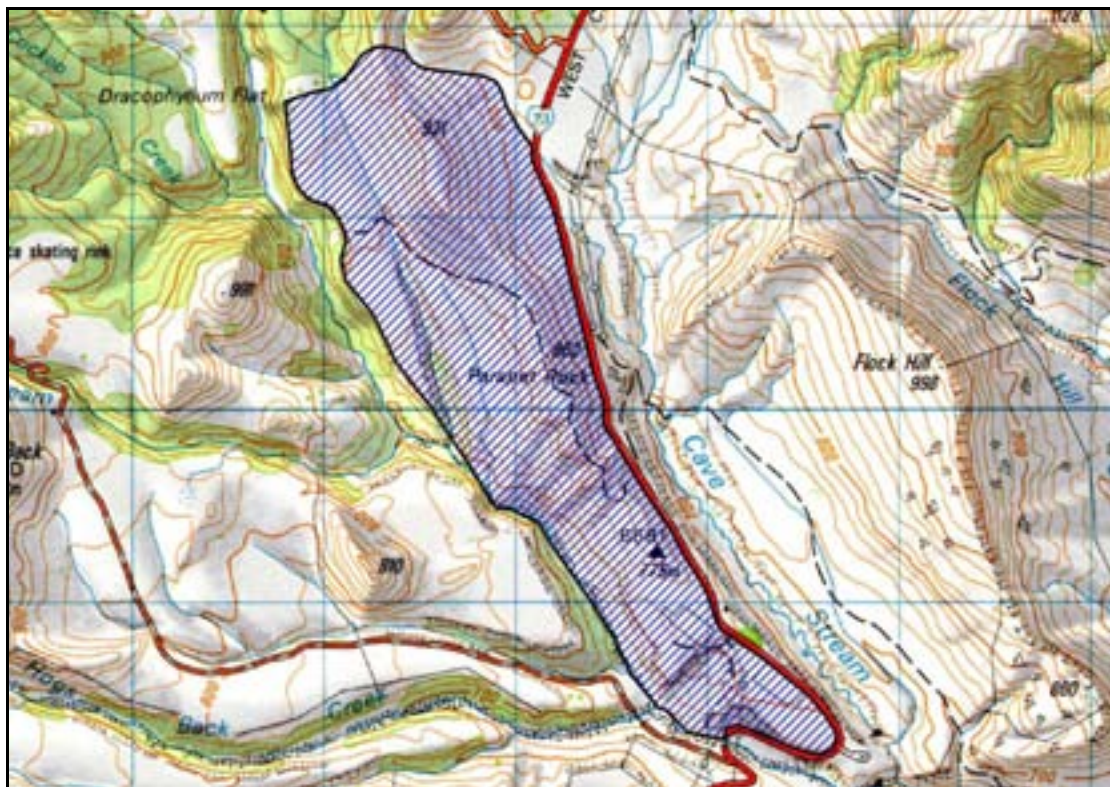


Figure 6 – Western Control Block

It is recommended that control of this block should be conducted by volunteers under the coordination of ECan. This is because the trees are still small enough to be easily removed by volunteers and containment is achievable. Some use of chainsaws will be necessary in places to support the mainly hand tool control effort. Given its location on the boundary of the property it should be targeted as a high priority.

C –Pylon Flats Control Block 125 hectares (Figure 7)

The large flat area immediately east of the SH73 opposite the two main entrances to the Craigieburn Forest Park, extending from the road to Cave Stream. The wilding tree infestation in this area has become significantly more obvious in recent years as a consequence of grazing pressure having been removed for a period. Grazing has now been continued but the vast majority of trees present are now too big to be effectively controlled or contained by sheep. Other control efforts need to be used to reset the clock before grazing pressure can again be successful at maintaining wilding tree spread in check.

Any control in this area needs to be supported by farming practices. Intensive grazing will limit wilding re-establishment after control, while fertilising and oversowing with pasture grasses will encourage greater competition from more favourable vegetation.

Transpower already undertakes wilding control across the Pylon Flats Block as a part of their regular maintenance programme under powerlines. They have had a marked impact on the size of trees in their management area, with those remaining typically very small and at considerably lower densities than occurs elsewhere on the flats. Their work effort is likely to increase as the remaining trees on the flat reach maturity and set seed.

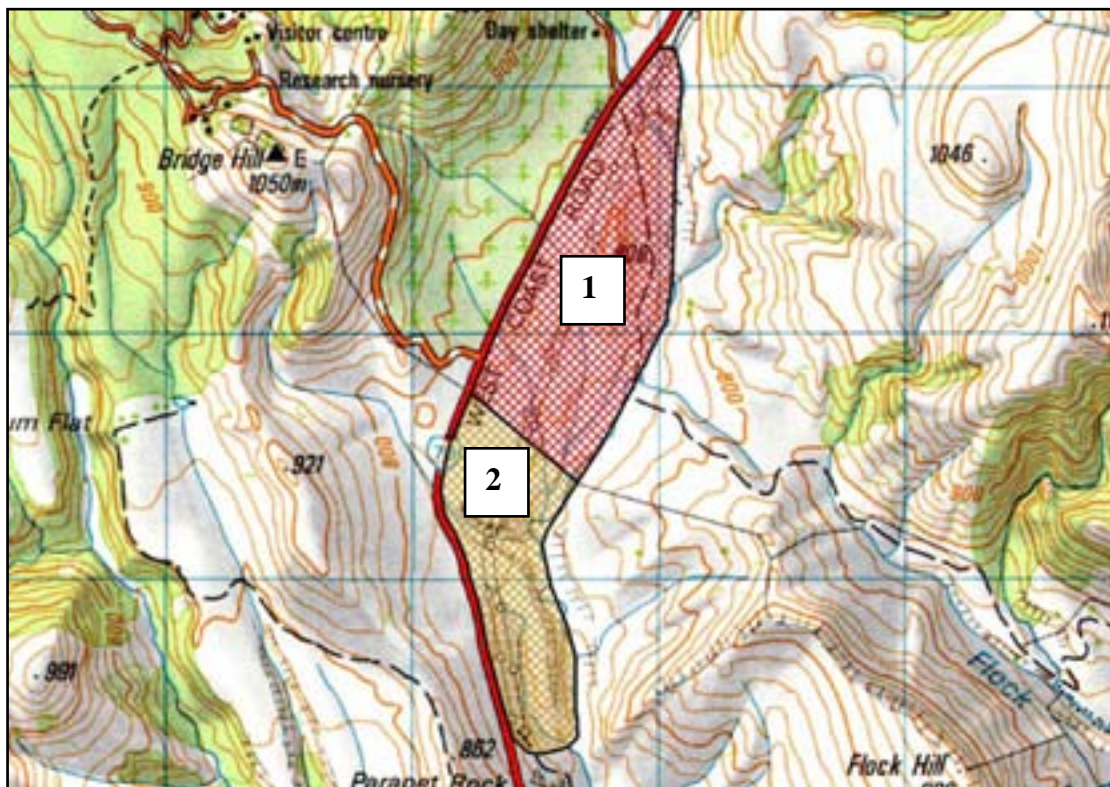


Figure 7 – Pylon Flats Control Block showing component control blocks as 1 (Northern Pylon Flats) and 2 (Southern Pylon Flats)

This area is highly visible to passing motorists on the state highway and as such represents a significant showcase opportunity for control. Control efforts in the area need to be collaborative as a reflection of the range of interests. It is a given that Transpower will continue their site specific work efforts, while Flock Hill Station

need to take some responsibility for the benefit of farming practices within the area. ECan is probably best suited to address the issue from the viewpoint of public amenity and landscape value.

It is recommended that this area is considered a high priority for reasons of the combined value to agriculture and aesthetics. However, if ECan were to apply RPMS criteria, control in this block would be a low priority. Further consideration needs to be given to the role which ECan would be prepared to have with respect to controlling wildings on the Pylon Flats Control Block.

Access to all parts of this block is very easy and the terrain will pose no difficulties. Any work conducted alongside the road needs appropriate safety measures.

C1 - Northern Pylon Flats Control Block (75 hectares) [Priority 6=]

This area extends north from a fence line almost opposite the Broken River Ski Field access road. It contains an area of extremely dense fringe regeneration emanating from an old plantation exclosure plot. The trees within the plot have already been removed twice but the emanating spread is rampant. Outside of this immediate area densities are significantly less but remain high to very high for the most part, except in the area under the main powerlines which are maintained at moderate to high densities.

That part of the block under the densest infestation is likely to be most easily controlled using machinery. It would be very easy to get a mulcher to the site and it is perceived that this represents one of the few sites on the property where such machinery could be efficiently employed. Spraying the site may be another option which could be worth investigating if the mulcher turns out to be impractical. The alternative of using ground crews is likely to be too costly by comparison.

Those areas of lesser density should be controlled by a contract ground crew using scrub bars. They are likely to be able to complete the control operation relatively quickly and with minimal ground disturbance compared to machinery. The lower densities combined with the undulating nature of the ground would make mulching impractical.

Control efforts on this part of the block need to be collaborative between Flock Hill Station and ECan. Transpower may also be in a position to provide financial assistance for work beyond its area of concern on the surmise that an investment now will reduce its ongoing costs. Ensis may also be in a position to provide some financial support by way of conducting research into scrub bar and mulching techniques as part of an ongoing project looking into the control of wilding trees in the high country. Further investigation of funding options may be necessary for this control block.

C2 – Southern Pylon Flats Control Block (50 hectares) [Priority 6=]

Extending south of the fence line almost opposite the Broken River Ski Field access road, this block contains trees at a significantly lower density than the Northern Pylon

Flats Control Block. An obvious grazing effect is evident at the fence, with densities ranging from moderate to high.

Control of this block is likely to be achievable by volunteers using hand tools, with some limited chainsaw support to control a few larger trees within an enclosure plot. Control in this area should be initiated by ECan as soon as possible, provided that it can assure volunteers that the adjoining area to the north is programmed for control.

D – Cluster Control Block 50 hectares (Figure 8) [Priority 21=]

Located between SH73 to the west and below the retirement fence on Broken Hill to the east, this block predominantly occupies a terrace south of Craigieburn Cutting. It is bounded by the Lower Western Slopes, Mid Slope, Upper Slopes and Northern Lower Slopes Control Blocks.

Wildings in this area are rampant, with two major clusters present and another in the early stages of development. Densities within the clusters are extremely high, with inter-cluster areas typically at high to very high densities. While the trees in this area do not pose any significant long-distance threat due to siting, their unchecked spread compromises the tussock grassland, shrubland and regenerating beech forest communities of the adjacent Craigieburn Cutting area and the western slopes of Broken Hill.

Any control in this area will involve a mix of methods. The main clusters are likely to be too expensive to control using ground crews. If it is possible to get a heavy mulcher to the site this may prove to be the most cost-effective method. Alternatively aerial spraying could be considered, at least around the edge of the stands in an effort to contain further spread. Spread between the stands could be controlled by ground based contractors using either chainsaws or scrub bars, although the latter is likely to be of limited practicality in the areas of shrubland.

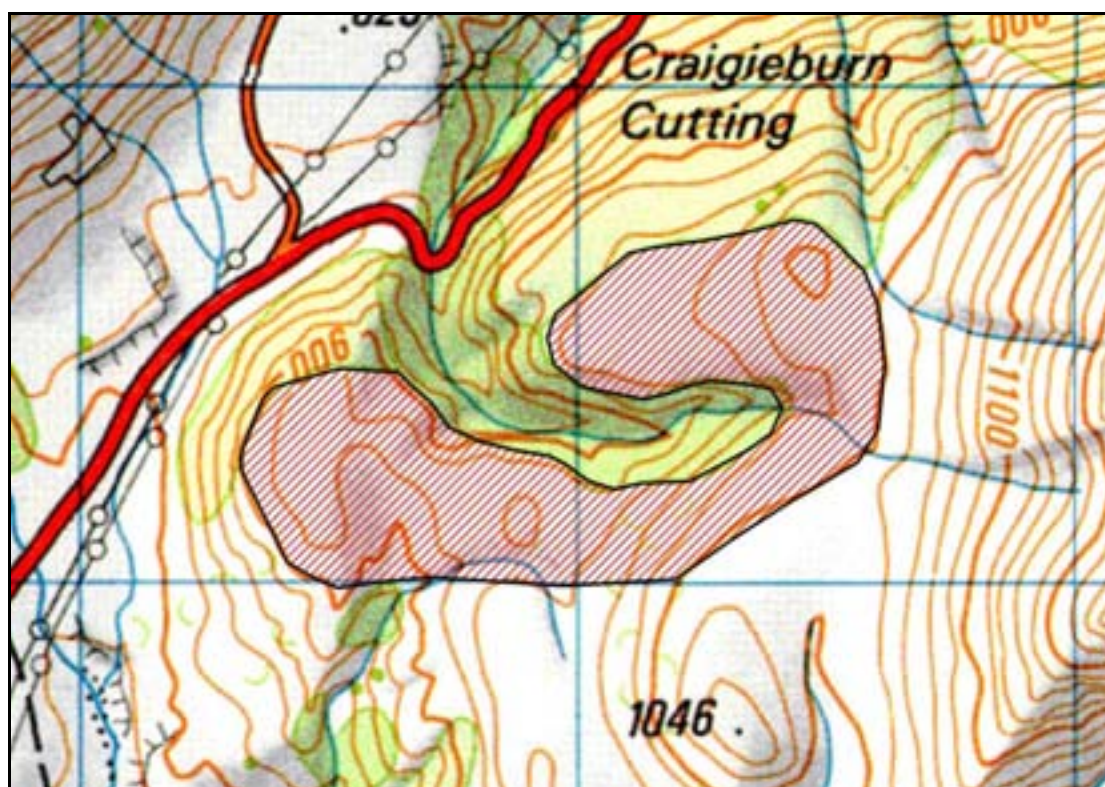


Figure 8 – Cluster Control Block

Access may prove difficult as there does not appear to be any obvious track. Further investigation should be made of the practicality of getting a mulcher on site. If this is not possible, the edge of the clusters should be sprayed in a progressive control manner. The recommendation is to at least conduct ground-based manual control of

the inter-cluster areas in the near future to prevent further in-filling. If aerial spraying is to be used, the need for resource consent will need to be investigated.

ECan should coordinate any use of ground-contractors or aerial spraying in this area, while Flock Hill Station may be in the best position to pursue the use of machinery.

E - Northern Lower Slopes Control Block 265 hectares (Figure 9)

That area bounded by SH73 to the west and the Flock Hill Station buildings to the north. The block goes up to the Broken Hill retirement fence for the most part, with those parts not fenced going up to approximately the 900 metre contour. The wilding trees in this area originated from plantings around the original homestead and as such should be the responsibility of Flock Hill Station to control. The terrain is typically steep sloped with dissecting gully systems, with some gentler slopes around the station buildings.

The trees in this area pose limited immediate threat to areas much beyond the existing spread. However, subsequent generations of wildings growing on the slopes are capable of travelling much further given their exposure to strong winds.

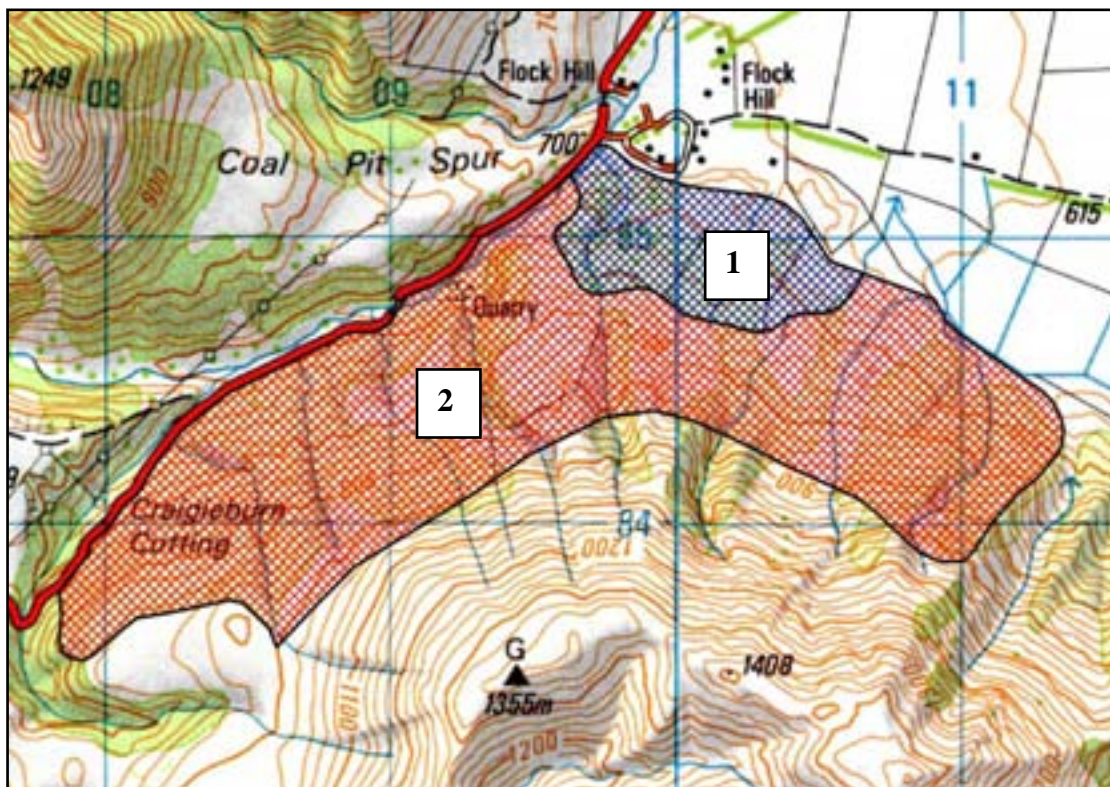


Figure 9 – Northern Lower Slopes Control Block showing component control blocks as 1 (Station Plantings) and 2 (Homestead Spread)

E1 – Station Plantings Control Block (40 hectares) [Priority 24]

The immediate area around the original plantings, containing densities ranging from moderate to very high. While the original plantings remain an important amenity value for the property, removal should be undertaken to control the associated wilding spread. It may also be practical to remove certain high spread-risk species from the plantings. A small stand of regenerating Douglas fir near the bridge to the property should be removed prior to maturity as it poses a significant threat to shrublands in the vicinity.

It may be possible to utilise some of the timber from the plantation for commercial purposes. A small portable milling operation could be supported by timber taken

from the area if so desired, while there may also be some potential value from small-scale harvesting. This is worthy of further investigation.

Access to the block is relatively easy although dense regenerating shrubland may cause some hindrance. While farm staff are more than capable of controlling areas of small trees using hand tools and chainsaws, it is most likely that contractors would be better suited for the safe and efficient felling of large trees.

E2 – Homestead Spread Control Block (225 hectares) [Priority 23]

The area of spread emanating from the original homestead plantings extending further up hill and along the faces from the Station Plantings Control Block. Densities are highest close to the plantings and rapidly decrease further away, with the range being from low to high on average. The area above Craigieburn Cutting that was burnt still appears to sustain only low densities of wildings, although this area was only viewed from the road for the purpose of preparing this report.

This is another block that farm staff may be able to effectively control although it may be more efficient to utilise contractors. Any operation on this block is likely to require the use of chainsaws as tree sizes are varied. Care needs to be taken when felling larger trees above the road to ensure that no material becomes a hazard to passing traffic.

While access is easy to lower parts of the block, getting to the upper reaches will be arduous, especially when carrying chainsaws and moving through regenerating shrubland. The block is also relatively large.

F – Upper Slopes Control Block 185 hectares (Figure 10)

The area extending around the north and north-east faces of Broken Hill, above the retirement fence and the Northern Lower Slopes Control Block. The source of trees in this area is a combination of the plantings at Helicopter Hill and around the Flock Hill Station buildings. The responsibility for conducting control in this area therefore needs to be shared.

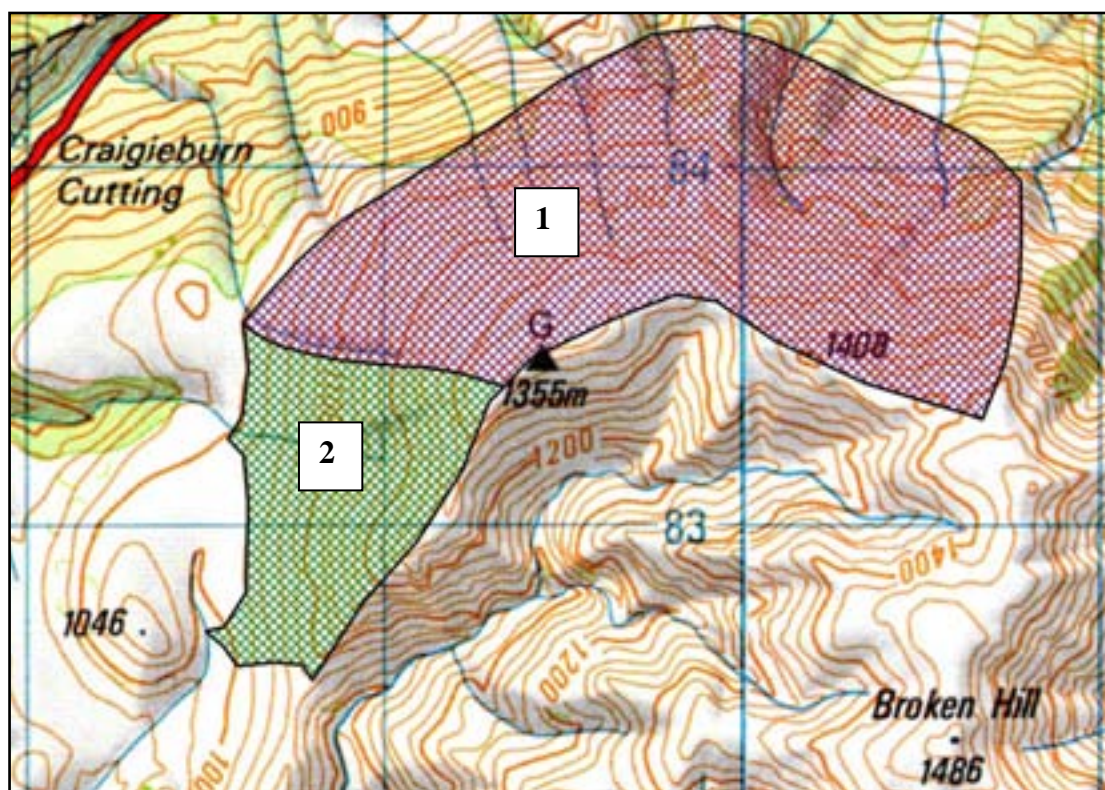


Figure 10 – Upper Slopes Control Block showing component control blocks as 1 (Flock Hill) and 2 (Helicopter Hill)

This area has never received control before and the erection of the retirement fence removed any potential effect from grazing. This is very noticeable, with a considerably higher proportion of large trees above the fence than below. Significant infilling has occurred in relatively sheltered gully systems, while for the most part the regeneration associated with mature trees on the faces is limited.

Densities are variable, ranging from low to high, with occasional clusters of very high density. The latter tends to occur in the sheltered gully systems and as such may not pose such a significant threat of distant spread in the short-term. However, those trees growing along the faces are of much greater concern as they are exposed to strong winds. Their location on high spread-prone sites warrants a relatively high priority for removal, with operations progressively working north from the southern part of the control block. The denser infestations can be left for progressive control over a number of operational seasons.

The terrain is steep and heavily dissected with gully systems. Access to the block is difficult and is likely to require helicopter ferry. For this reason the most efficient method of control would involve a team of contractors with chainsaws doing contour

sweeps. Particular care would be necessary to ensure that staggered lines are maintained to ensure the safety of all operators. There may also be considerable damage caused to the fence as a consequence of rolling trees. This will need to be monitored and repaired, depending on the grazing status of the land immediately below.

Due to the likely involvement of helicopters for access it would be most efficient to conduct collaborative operations over both sections of the block at the same time, using teams of 6-8 operators.

F1 – Flock Hill Control Block (140 hectares) [Priority 10=]

The northern-most portion of the control block, the trees in this area are the result of spread from the plantings around station buildings. As such, Flock Hill Station should take responsibility for control operations here.

While the area is large, the densities are typically moderate with the exception a dense infill gully on the boundary with the Helicopter Hill Control Block.

F2 – Helicopter Hill Control Block (45 hectares) [Priority 2=]

Trees in this part of the block are likely to have come from both the plantings on Helicopter Hill and around the station buildings. Due to the variable sources it is considered that ECan would be the most appropriate control agency, with possible financial support from DOC.

This area contains a couple of significant infill gully systems with high to very high tree densities. These need to be controlled from the bottom upwards so as to ensure that operators do not have to work below felled trees. Safe routes for daily access should be easy to maintain in the regenerating shrublands typically associated with these systems.

G – Back Gully Control Block 238 hectares (Figure 11) [Priority 15]

This control block is the steep valley system to the north-east of the Broken Hill summit, which drains into Flock Hill Stream. It is bounded by obvious ridgelines and finishes in a substantial area of forest at the down-valley end.

The area is somewhat sheltered from the prevailing winds and as such contains relatively few trees for the most part. Occasional patches of trees were observed from the ground and air but overall densities remain low. While the threat to adjoining areas of spread from this area is low, this represents a site where significant control can be achieved over a large area for a relatively small cost. This is a main consideration when setting priorities.

The difficult access, steep terrain and very low densities make this an ideal site for conducting an aerial control operation. Skid-hopping is likely to be the most efficient technique over large parts of the block due to its ability to use a larger team of people. However, some trees growing in very steep or bluff terrain may require the services of a specialist human-sling team.

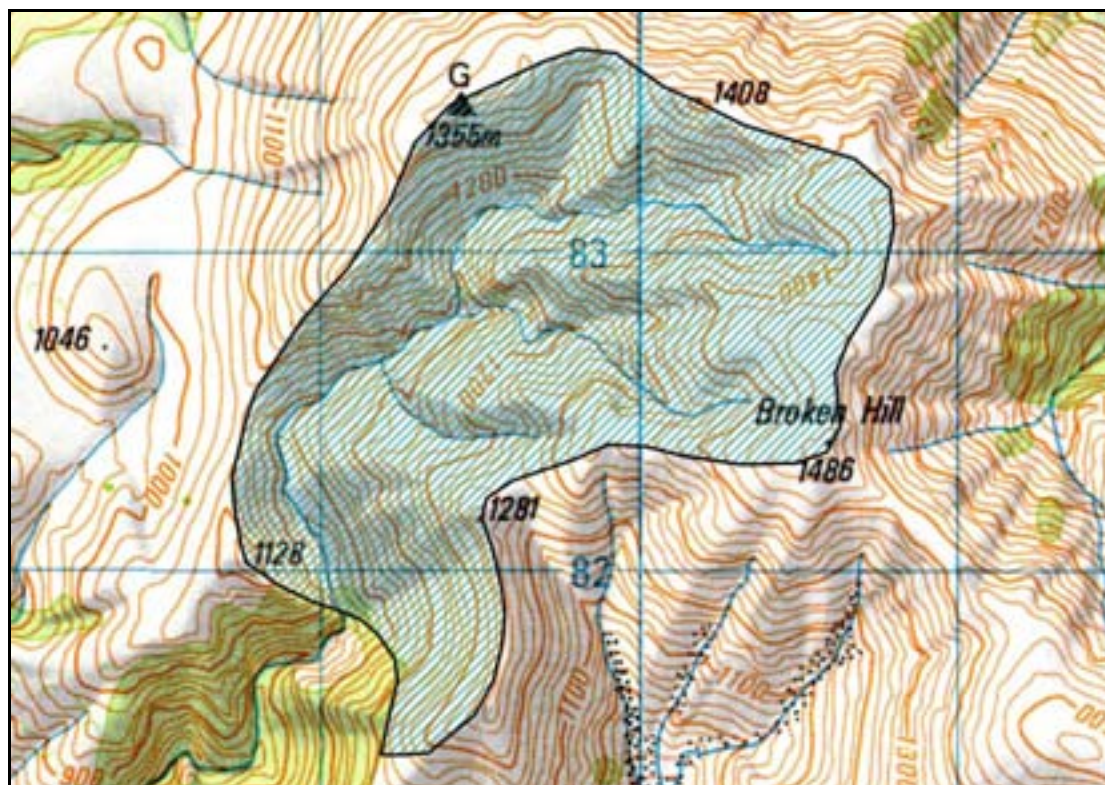


Figure 11 – Back Gully Control Block

This operation should be conducted by ECan. It may be possible to utilise DOC staff experienced in this technique to carry out the work. ECan staff could also be used in areas of denser infestation. Otherwise experienced contractors should be utilised, particularly for any strop operation.

H – Infill Basin Control Block 30 hectares (Figure 12) [Priority 26=]

A dense infill cluster in a sheltered basin below the western ridge of Broken Hill. Spread in the area has obviously been contained in the past by the grazing pressure of stock as is evident by a distinct fence effect beside the stand. This can be seen in Figure 3. Densities within the stand are very high to extreme, with more scattered regeneration occurring around the fringes.

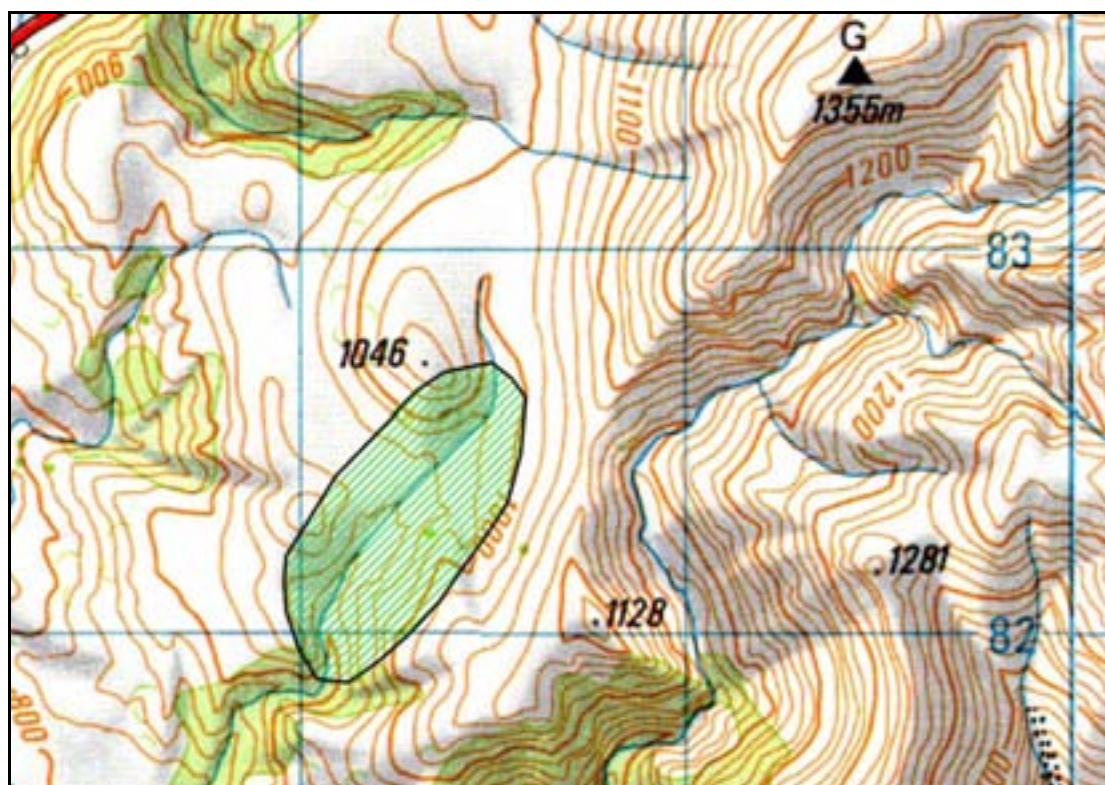


Figure 12 – Infill Basin Control Block

The sheltered nature of this stand makes it of very low risk to downwind areas, despite its location high up on Broken Hill. The scattered spread surrounding the stand is of more concern as that is steadily spreading towards high risk “take-off” sites. Contractors using chainsaws should be utilised to control the scattered spread and essentially contain the denser stand. Control of the stand itself can be left till much later in the control programme. Once resources are available for its control they can either be utilised to employ ground contractors with chainsaws or for aerial spraying. The former will be considerably more expensive but is likely to achieve a satisfactory result the quickest.

Access to the block can be obtained via a farm track along Flock Hill Stream, but it will require an uphill walk each day. Once on the block the terrain is gentle. Regenerating shrubland may hinder progress. ECan should be responsible for any control effort in this area.

I – Western Ridge Control Block 33 hectares (Figure 13) [Priority 1]

Located below the highest point on the western ridge of Broken Hill, this block is on the uphill side of the Infill Basin Block. Seed dispersed from this significant “take-off” site directly threatens large areas of downwind land, with seed likely to reach as far as the Torlesse Range. This makes it the single highest priority for control on all of Flock Hill Station at the current time. There are already coning trees present in high density clusters.

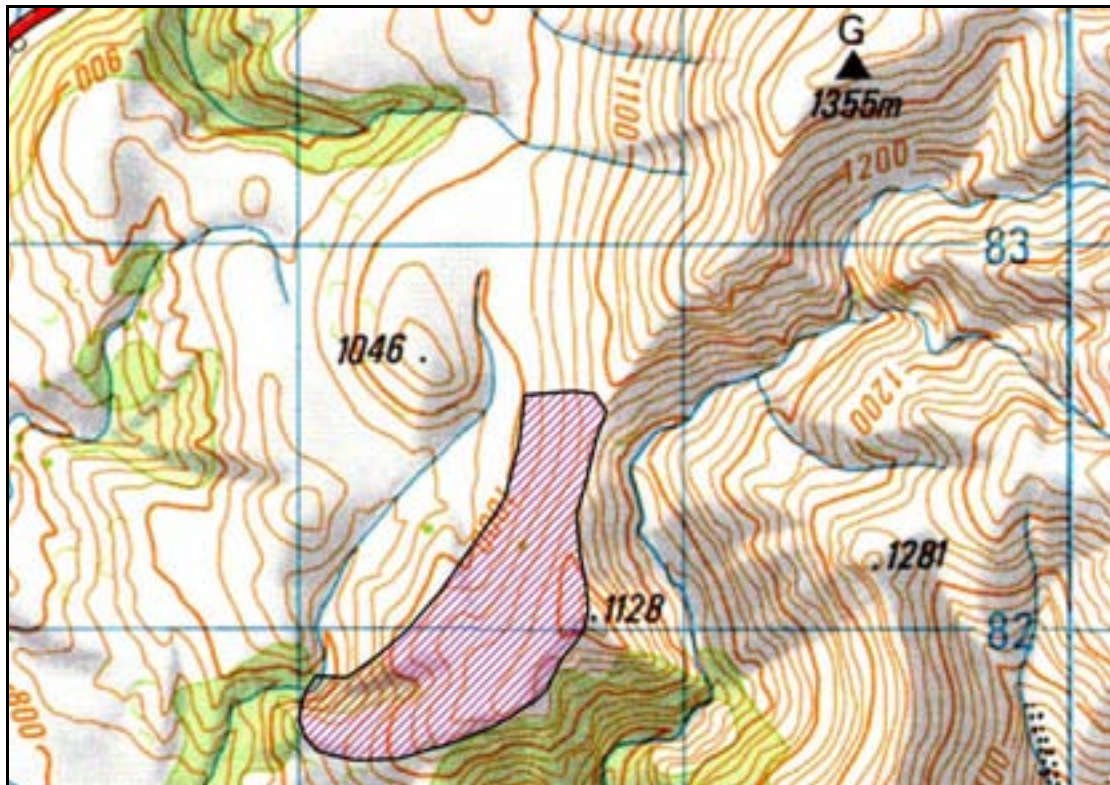


Figure 13 – Western Ridge Control Block

Chainsaw contractors should be utilised in this area as soon as possible. This is likely to be an area where DOC would be prepared to initiate control on the basis that it poses an immediate threat to its substantial investments on the Torlesse Range.

Access could be reached from a track in Flock Hill Stream but would require a daily climb to the worksite. It would be beneficial to utilise a helicopter at the start of the operation to get staff, equipment and spare fuel up to the site. The increased cost would be offset by greater productivity associated with having all gear on site and by using the machine for other work in the area.

J – Mid Slope Control Block 132 hectares (Figure 14) [**Priority 10=**]

Includes an area of obvious high points and wetlands on the western side of Broken Hill, extending south from the edge of the Cluster Control Block. This area contains widespread scattered trees and several large clusters, including the one shown in Figure 2. Densities range from moderate to very high.

This area poses a high risk of spread to downwind areas and as such requires a high priority status. There is also a localised threat to the wetland areas contained within the block which represent a significant community for protection.

Contractors using a mix of hand tools and chainsaws will be necessary, most likely at the instigation of ECan. Access can be easily obtained using a track along Flock Hill Stream. The terrain is relatively easy going although care will be necessary around a series of rocky bluffs and outcrops.

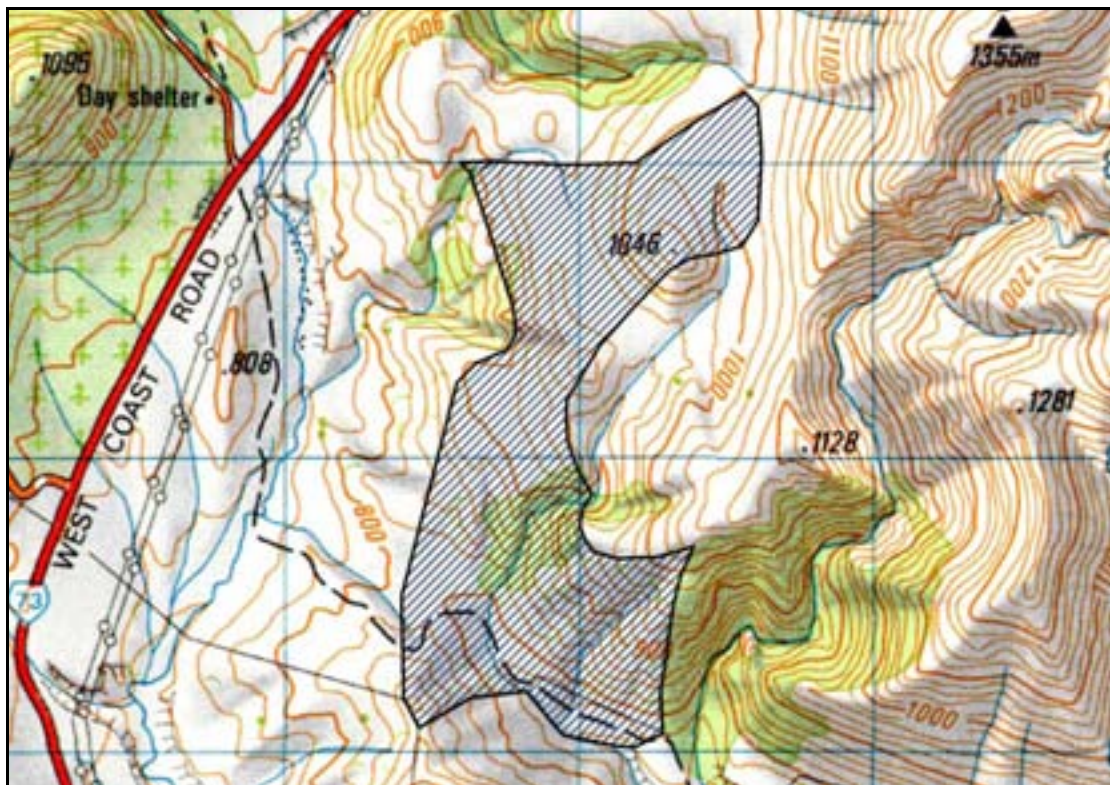


Figure 14 – Mid Slope Control Block

K – Western Lower Slopes Control Block 185 hectares (Figure 15)

That area east of SH73 extending from opposite the Craigieburn Ski Field access road to below Parapet Rock. It covers the lower slopes immediately above the Pylon Flats Control Block, with a section of road frontage at the northern end. This area has seen considerable infilling over recent years, with a large number of clusters now evident. Densities are typically high or greater throughout.

The threat of spread from these areas is likely to only be realised in the immediate vicinity, but the loss of valuable grazing concern within the block is of agricultural concern. It is recognised that these lower slopes present valuable pasture and as such Flock Hill Station needs to assist with any control effort here. The scale of the problem is such that the station could not deal with it on its own and therefore ECan will need to be a major contributor to the work effort. Any control operation needs to be augmented by subsequent oversowing and topdressing with intensive sheep grazing to limit the amount of ongoing regeneration.

Access throughout is easy, with the terrain typically gently sloping. The block can be divided into distinct zones according to natural breaks in the infestation.

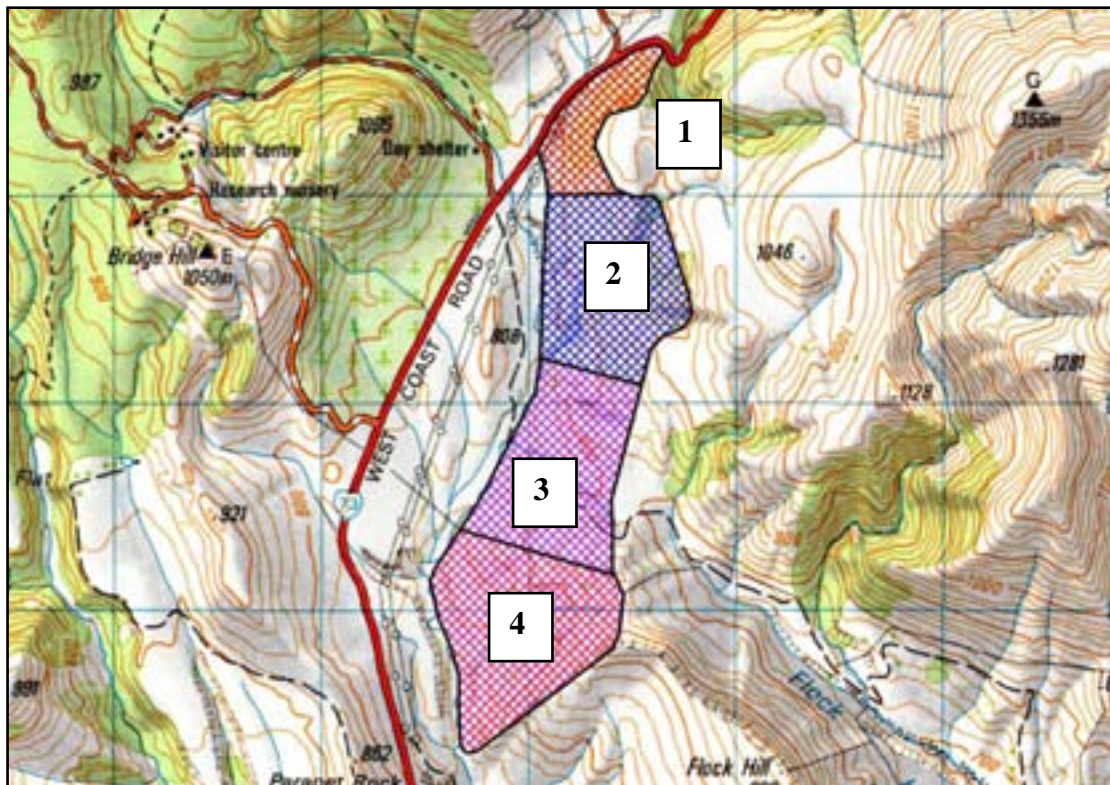


Figure 15 – Western Lower Slopes Control Block showing component control blocks as 1 (North End), 2 (Stream Zone), 3 (Track Side) and 4 (South End)

K1 – North End Control Block (20 hectares) **[Priority 19=]**

Located in the area between the highway and the Cluster Control Block. High tree densities in this area could be quickly controlled by contractors using a combination of hand tools and chainsaws at relatively low cost, although it may also be practical to use station staff. It would be preferable to do this reasonably soon as the trees grow

rapidly at these lower altitudes and with that costs increase. Care would need to be taken when working adjacent to the road.

K2 – Stream Zone Control Block (53 hectares) [Priority 25]

An area of predominantly very dense regeneration occurring around a small tributary of Cave Stream. It is most likely that contractors using a mix of hand tools, scrub bars and chainsaws will be most effective, although the presence of regenerating scrub may make it awkward for scrub bars. There may be some limited potential for using a mulcher in parts of this block as well although this would need some further investigation. The use of chemicals is not recommended due to the proximity to water and the presence of wetland vegetation in parts.

This block is likely to require the most work amongst the Western Lower Slopes Control Block. Intensive grazing pressure here is likely to have a negative impact on associated conservation values and therefore physical control operations are more favourable for maintenance.

K3 – Track Side Control Block (52 hectares) [Priority 21=]

Covering an area on either side of the farm track which crosses into Flock Hill Stream, this block contains sporadic areas of high to very high density. The infestation in other parts appears to be at much lower densities or the regeneration is still too small to see from a distance. Due to the prevalence of regenerating shrubland in parts it is recommended that contractors using hand tools and chainsaws would be the most appropriate control mechanism.

K4 – South End Control Block (60 hectares) [Priority 19=]

Uncontrolled spread of trees in this area is likely to threaten the adjoining Cave Stream Control Block. As such it needs to be controlled as a reasonable priority to support any work conducted in the latter. Occasional mature trees were observed from a distance with considerable young regeneration in parts. Typical densities are likely to be moderate to high, with only isolate patches greater than this. Contractors using hand tools and some chainsaws should be able to achieve control in this part of the block relatively quickly and comparatively inexpensively.

L – Cave Stream Control Block 376 hectares (Figure 16) [Priority 8]

The western faces of Flock Hill from the ridgeline down to Cave Stream and the road beyond, extending from Parapet Rock to the Cave Stream Scenic Reserve. This area contains an alarming number of small trees that have largely been missed in previous control efforts in the area. Tree densities across the block range from low to high, with the greatest densities present at the northern end. A number of large trees were also observed from the air around rock tors at the south end of the block.

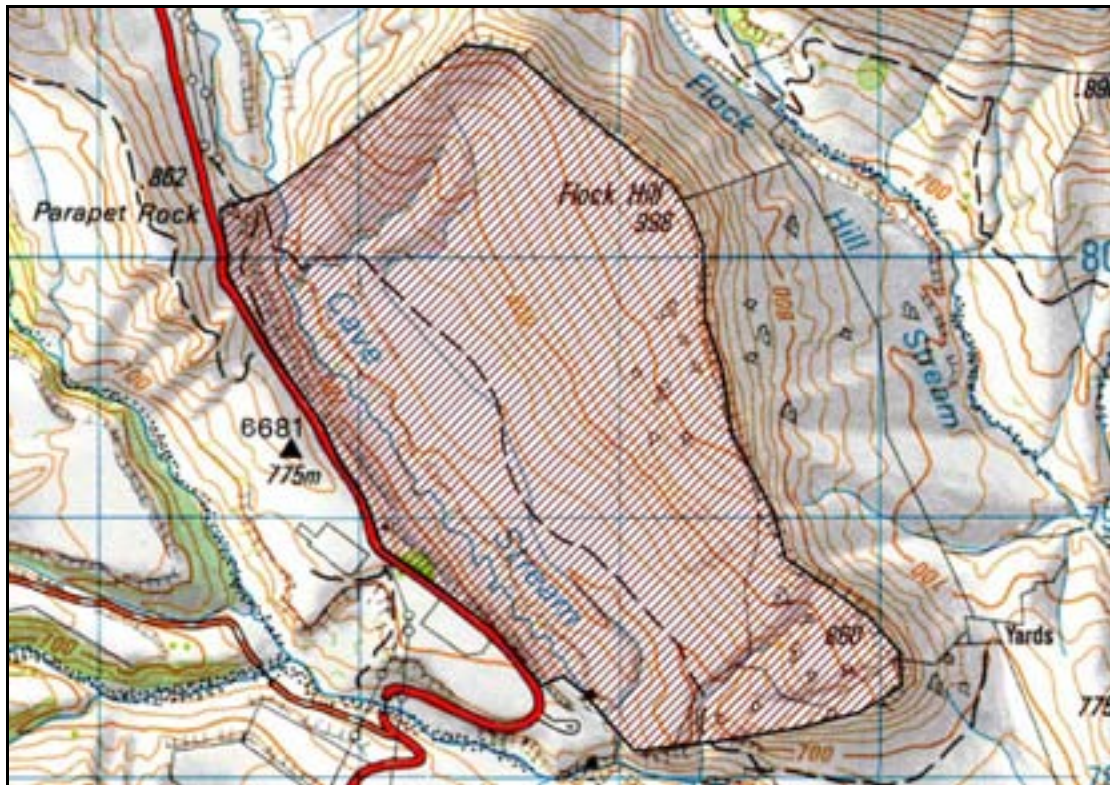


Figure 16 – Cave Stream Control Block

Both terrain and access is very easy, while the predominant grassland vegetation will make for ease of control. As the trees here are still relatively small and control is extremely achievable it is recommended that this site be controlled by volunteers using hand tools, with support from ECan to cut out any larger trees with chainsaws. This is recommended as a high priority given the location at the downwind extremity of the immediate infestation

Continued grazing around Flock Hill, Cave Stream and the associated limestone rocks is desirable for management. This will reduce the reinvasion potential of wilding trees and may also maintain predominant vegetation communities in a form that sustains the unique plants of the area.

M – Flock Hill Stream Control Block 600 hectares (Figure 17)

A significant area of wilding tree spread on the south faces of Broken Hill. Ongoing volunteer efforts over recent years further south and east of here have effectively pulled back the main extent of mature trees to this point. As the most downwind of the main control blocks, with the exception of parts of the Cave Stream and Aerial Control Blocks, this area represents a key area for halting the continued spread of dense wilding trees.

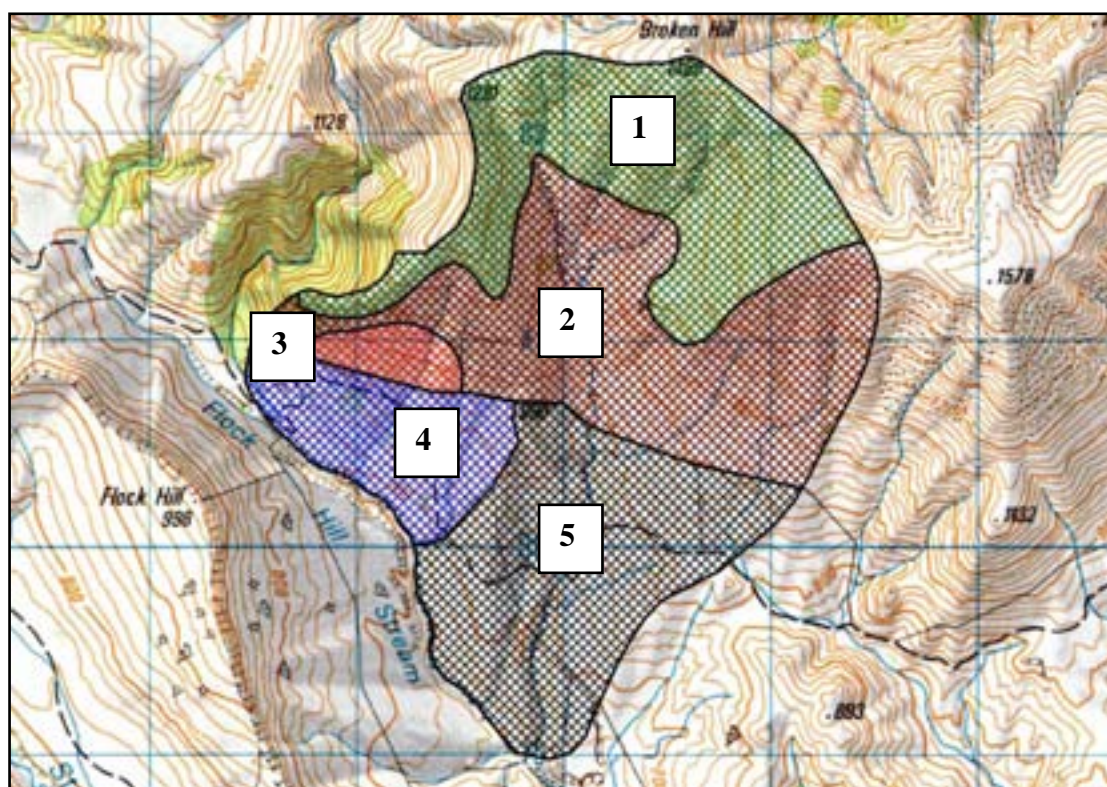


Figure 17 – Flock Hill Stream Control Block showing component control blocks as 1 (Take Off Zone), 2 (Scattered Zone), 3 (Dense Stand), 4 (Dense Regeneration) and 5 (Volunteer)

Seed arrived in this location very early on, possibly as a consequence of the first major long-distance wind event in 1977. Evidence for this is in the presence of some very mature individuals surrounded by multiple generations of younger trees. The fact that a significant part of this block was allowed to infill to very high densities suggests that the area is relatively sheltered. This was supported by ground inspections conducted under strong north-westerly conditions, which highlighted that areas near the ridgelines pose a major threat to vulnerable downwind lands while trees along the lower slopes are only really threatening the immediate vicinity.

Access to most of the block is easy along a farm track at the base of the slope, although it will require a reasonable amount of time for travel. Gaining access to upper parts of the block would be far more efficient if utilising a helicopter. Terrain ranges from gentle toe slopes to deeply incised upper reaches. The steep nature of the upper parts of the block will make work conditions difficult for contouring and extreme care will need to be taken with rolling rock and debris.

Work in this control block should be conducted by ECan, although DOC may be in a position to contribute some funds or resources to remove trees from spread prone sites due to the imminent threat to its downwind investments.

M1 – Take Off Zone Control Block (160 hectares) [Priority 2=]

Located along ridgelines and the upper slopes of the block, this represents that part which poses greatest threat of distant spread. Seed from here is capable of travelling reasonably long distance due to the elevation of source trees and exposure to the strong prevailing winds. It is likely that seed would reach the Torlesse Range in a single spread event. As such this is recommended as a very high priority for control, towards which DOC may be prepared to contribute.

Densities typically range from low to moderate, with isolated patches of high density trees. Control work should be conducted by contractors with chainsaws doing contour sweeps. Despite the large area involved it is likely that a team of 5-6 operators could complete control within a week.

The fact that this block is likely to be controlled before work is conducted in the lower part of the overall site may pose some concerns with rolling debris during later operations. This should not be a major problem but as a precaution, subsequent control work in the immediate down-slope area should be avoided on windy days.

M2 – Scattered Zone Control Block (190 hectares) [Priority 17]

Considerably more sheltered than the Take Off Zone Control Block, this area represents a significant area of medium to high density scattered threat with occasional higher density clusters. While it is of lesser concern for long distance spread, the fact that it is relatively sheltered means that the area will quickly infill with trees resulting in rapidly escalating costs of control. It is therefore recommended that work here is conducted as soon as practical to restrict the potential of spread extending further. This will also protect the already considerable investment of volunteer efforts in the immediate downwind vicinity.

This area should be controlled using a team of chainsaw contractors starting from the bottom and working upwards. In order to improve efficiency it may be possible to control the upper parts of the block as part of helicopter access operations in the Take Off Zone Control Block. Care will be needed to avoid damage to fences at the base.

M3 – Dense Stand Control Block (15 hectares) [Priority 12]

This area contains varying ages of trees at very high density above the retirement fence. Mature specimens of all the key spread species are present, namely lodgepole, Scots and dwarf mountain pines and Douglas fir, along with associated regeneration. The area is reasonably large and will therefore require a substantial commitment for control.

The immediate threat is limited to adjacent areas of close proximity and as such it is a lower priority. However, the presence of mature seeding trees in a location at the downwind extent of the total area of spread makes it of critical concern for the

ongoing future management of the wilding problem in the Basin. As such some interim effort should be conducted here in the short-term to contain the risk of further spread.

It is recommended that the most practical method for controlling this block in the short-term is by aerial spraying. There is likely to be a need for physical felling methods to be used at some point, particularly around the fringe, but this effort could be delayed. Aerial spraying could target just the outside edge of the dense infestation to at least contain the spreading potential, although it would be more appropriate to spray the entire area if budgets permitted. Maintenance spraying operations would need to be rescheduled for subsequent years, with any associated ground based work conducted in a few years as other higher work priorities are completed. Ground-based efforts should not be delayed too long due to the safety issues associated with working around dead or dying trees.

M4 – Dense Regeneration Control Block (70 hectares) [Priority 18]

That area on the gentle lower slopes below the retirement fence. Previous grazing pressure in the area has had a marked impact on seed establishment, with those trees present typically small with the exception of a large cluster at the western point. There are also mature trees growing in pockets within the beech forest. Densities range from high to very high for the most part.

Contractors mainly using hand tools will be successful at controlling this block, provided that it is done in the near future before the trees grow much larger. Chainsaws will be required for achieving control of the larger trees at the western point of the block.

Intensive grazing pressure will be very important to maintain control over this part of the block following initial control operations. This should remove any young trees that manage to establish from remaining seed sources above the retirement fence. Long-term control in the area will require these seed sources to be totally removed.

M5 – Volunteer Control Block (165 hectares) [Priority 16]

Trees in this area have already been removed over recent years as a result of volunteer efforts organised by ECan. As a consequence, the trees present are typically small and widely dispersed at low to moderate densities. Occasional larger trees can be found in pockets of regenerating shrubland in places.

Hand tools will be sufficient for tree removal on this block, at least in the short term, with some support from chainsaw operators. It is therefore recommended that large teams of volunteers continue to be coordinated to carry out control in this area at regular intervals. Given the location at the most downwind extent of the infestation on Flock Hill Station such operations should be commenced as a high priority. This will limit any further significant spread over short distances as well as ensuring that control remains easily achievable.

As with the other regeneration block below the retirement fence, intensive sheep grazing will have a vital role in limiting further seedling establishment in the area.

This will result in less target trees for subsequent maintenance operations, although vigilance will need to be continued.

N – Aerial Control Block 1150 hectares (Figure 18) [**Priority 5**]

This block essentially represents the remaining areas of steep slope on Broken Hill that are not already included in other control blocks. A combination of the predominantly low to very low densities, large area, steep dissected terrain and access difficulties mean that this site is ideally suited to a helicopter based operation involving skid-hopping.

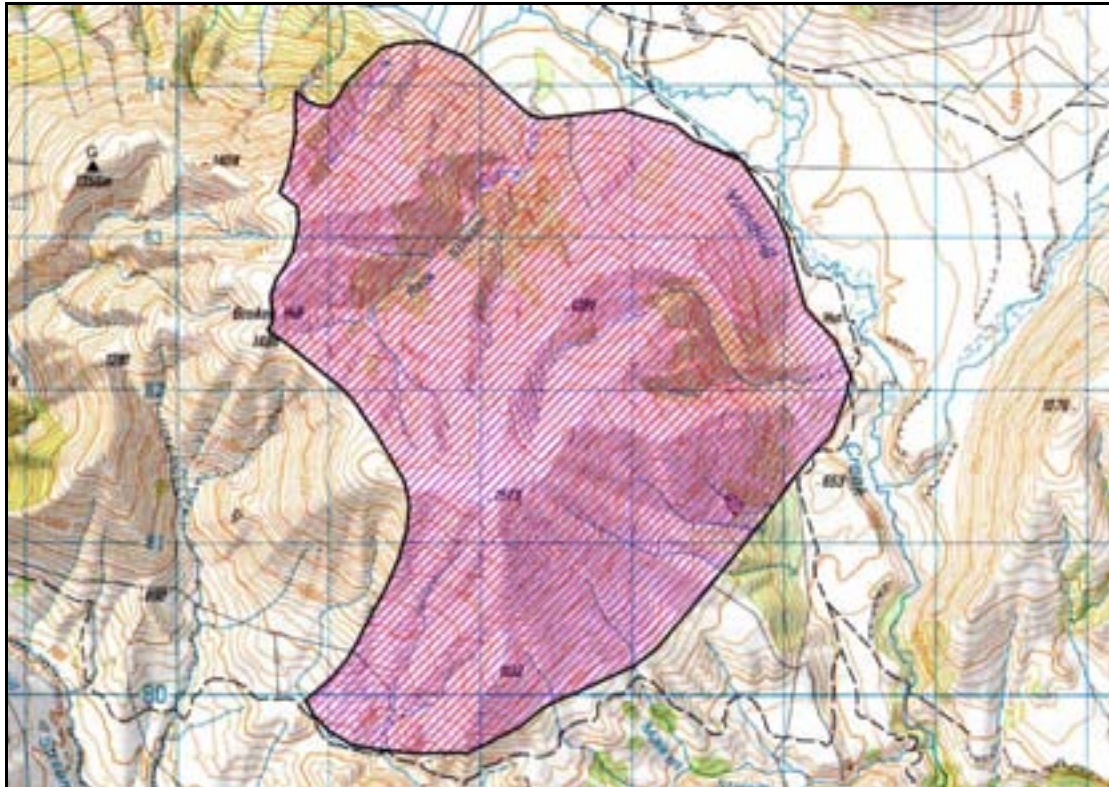


Figure 18 – Aerial Control Block

The spread potential of mature trees on this site is relatively low but will only increase as time progresses and densities get higher. The time is right to remove all trees on the block before that increasing threat is realised. An operation involving experienced operators in the near future would achieve considerable gains over a substantial area for a very low cost. As such this operation is recommended as a high priority.

It may possible to utilise DOC staff for this operation, which is only likely to take a day at the most for a team of 5-6. Alternatively contractors experienced in working around helicopters could be used.

Ongoing inspections of other sites

The inspections conducted for the preparation of this report did not extend to areas east of Winding Creek or along the eastern slopes of Flock Hill down to Flock Hill Stream. The assumption has made that any wilding trees present are at very low densities. This needs to be further investigated. While these areas may not currently be affected by wilding tree spread, their downwind location places them at high risk from potential invasion. Efforts within the identified control blocks will reduce this risk.

It is recommended that vigilance is maintained in these areas, with visual inspections carried out at regular 2-4 yearly intervals. This could be done from either the ground or the air, although aerial inspections may not readily identify very early stages of an infestation. The associated cost of these inspections is negligible compared to that of not detecting infestations until they are already well established. In most circumstances station staff would be in the best position to conduct inspections as part of general farm management.

15 SUMMARY TABLES OF OPERATIONAL CONTROL BLOCKS

These tables represents the area, average density of infestation, control priority, control mechanism, responsible agency, frequency of return for maintenance operations and costs associated with each of the control blocks described in section 14 – Operational Control Blocks. Refer to Appendix A for an overview map of all control blocks.

Table 6 – Summary of Operational Control Blocks outlining their respective costs and priority ranking

Reference (Page)	Control Block	Area (hectares)	Density	Priority	Justification	Control Mechanism	Agency	Return Period	Total Cost
A (44)	Bridge Hill								
A1 (44)	Exotic Plantings	104	M-H	26=	Limited immediate threat	Staff/Contractors	FHS	3-4 yearly	16,000 ¹
A2 (45)	Summit Stand	6	VH	4	Mature trees on take-off site	Contractor	ECan	1-2 yearly	3000
A3 (46)	Ski Field Access	20	VH	9	High threat to adjoining area	Staff/Contractors	ECan/DOC	3-4 yearly	30,000 ²
A4 (46)	South Face	50	M-VH	13=	Protect previous investment	Contractors	ECan	3-4 yearly	10,000
B (47)	Western	326	H	13=	At extent of spread	Volunteers	ECan	2-3 yearly	650
C (48)	Pylon Flats								
C1 (49)	Northern Pylon Flats	75	H-E	6=	Agriculture and aesthetic	Staff/Contractors	FHS/ECan	3-4 yearly	32,000 ³
C2 (49)	Southern Pylon Flats	50	M-H	6=	Small trees and achievable	Volunteers	ECan	2-3 yearly	100
D (51)	Cluster	50	H-E	21=	Limited distant spread likely	Staff/Contractors	FHS/ECan	2-4 yearly	35,000
E (53)	Northern Lower Slopes								
E1 (53)	Station Plantings	40	M-VH	24	Limited distant spread likely	Staff/Contractors	FHS	3-4 yearly	25,000 ^{2,4}
E2 (54)	Homestead Spread	225	L-H	23	Exposure to strong winds	Staff/Contractors	FHS	3-4 yearly	20,000 ^{2,4}
F (55)	Upper Slopes								
F1 (56)	Flock Hill	140	M-VH	10=	Exposed site	Contractors	FHS	3-4 yearly	18,000
F2 (56)	Helicopter Hill	45	M-VH	2=	Exposed site	Contractors	ECan/DOC	3-4 yearly	15,000
G (57)	Back Gully	238	L	15	Major control for low cost	Staff/Contractors	ECan/DOC	3-4 yearly	5000
H (58)	Infill Basin	30	VH-E	26=	Low immediate spread risk	Contractors	ECan	3-4 yearly	70,000 ⁵
I (59)	Western Ridge	33	H	1	Greatest threat to other areas	Contractors	DOC	3 yearly	15,000
J (60)	Mid Slope	132	M-VH	10=	Immediate threat	Contractors	ECan	3-4 yearly	30,000
K (61)	Western Lower Slopes								
K1 (61)	North End	20	H	19=	Trees currently still small	Staff/Contractors	FHS/ECan	4-5 yearly	4000
K2 (62)	Stream Zone	53	VH	25	Lots of work for little gain	Contractors	FHS/ECan	3-4 yearly	30,000
K3 (62)	Track Side	52	H-VH	21=	Limited distant spread likely	Contractors	FHS/ECan	3-4 yearly	20,000
K4 (62)	South End	60	M-VH	19=	Threat to adjacent area	Contractors	FHS/ECan	4-5 yearly	10,000
L (63)	Cave Stream	376	L-H	8	Location at extent of spread	Volunteers	ECan	2-3 yearly	750
M (64)	Flock Hill Stream								
M1 (65)	Take Off Zone	160	L-M	2=	Significant spread threat	Contractors	ECan/DOC	3-4 yearly	10,000
M2 (65)	Scattered Zone	190	M-VH	17	Threat to cleared areas	Contractors	ECan	3-4 yearly	20,000
M3(65)	Dense Stand	15	VH	12	Mature trees at spread extent	Contractors	ECan	1-2 yearly	7500 ⁶
M4 (66)	Dense Regeneration	70	H-VH	18	Mainly small trees	Contractors	ECan	3-4 yearly	20,000
M5 (66)	Volunteer	165	L-M	16	Previously controlled	Volunteers	ECan	2-3 yearly	350
N (68)	Aerial	1150	VL-L	5	Major gain for minimal cost	Staff/Contractors	ECan/DOC	3-4 yearly	8000
	Total	3875							455,350

¹ Based on half of the total area requiring control

² Cost likely to be significantly less if staff involved due to the economics of hiring contractors

³ Assumes that part of the area will still be controlled by Transpower as part of ongoing network maintenance (figures to be adjusted if this is not the case)

⁴ Total cost based on a mix of techniques and does not account for any potential removal at no cost due to commercial return

⁵ Assumes ground based control operation – aerial spraying would be a fraction of this cost, but would still involve some physical control

⁶ Based on the entire block being sprayed in a single operation

Notes to table:

Reference (Page)	Refers to the prefix allocated to each Control Block and any component parts, with the page number for the relevant section of text
Area	Not all of the area is considered to be under the densities specified
Density	Uses abbreviations according to identified categories in Table 5
Priority	Ranked in descending order of priority, with 1 being highest.
Total Cost	Represents the cost of first stage initial control only. Figures used in calculating total cost are based on perceived site conditions and the average costs presented in Table 4. They are rounded to nearest thousand, with the exception of those operations involving volunteers which are rounded to the nearest fifty.
Agency	Any operation involving volunteers is best coordinated by ECan due to its experience and contacts for conducting such work. FHS stands for Flock Hill Station
Mechanism	Operations will involve ground-based techniques unless otherwise specified. Where operations involve machinery or aerial spraying they will be undertaken by contractors, while aerial skid-hop operations may involve staff and contractors.

All costs are only indicative and will need validating after some work has been conducted, taking into considerations all of the variables

The priorities listed in Table 7 are only indicative and should not be viewed as the essential order for control operations. In reality the control priorities relative to different agencies will undoubtedly result in operations not following a strict chronological order overall. Practicalities may also dictate that sites are controlled out of order. It may be that multiple blocks are controlled concurrently as logistics permit and this is recommended where adequate funding and resources are available.

Table 7 – Priority ranking (listed in descending order) of Operational Control Blocks with associated main methods of initial control

Priority	Operational Control Block	Reference (Page)	Main methods of initial control
1	Western Ridge	I (59)	Chainsaws
2=	Take Off Zone	M1 (65)	Chainsaws
2=	Helicopter Hill	F2 (56)	Chainsaws
4	Summit Stand	A2 (45)	Aerial spraying
5	Aerial	N (68)	Aerial Skid-hop
6=	Northern Pylon Flats	C1 (49)	Mulcher, scrub bars
6=	Southern Pylon Flats	C2 (49)	Hand tools
8	Cave Stream	L (63)	Hand tools
9	Ski Field Access	A3 (46)	Chainsaws, hand tools
10=	Mid Slope	J (60)	Chainsaws, hand tools
10=	Flock Hill	F1 (56)	Chainsaws
12	Dense Stand	M3 (65)	Aerial spraying, chainsaws
13=	Western	B (47)	Hand tools
13=	South Face	A4 (46)	Chainsaws, hand tools
15	Back Gully	G (57)	Aerial skid-hop
16	Volunteer	M5 (66)	Hand tools
17	Scattered Zone	M2 (65)	Chainsaws
18	Dense Regeneration	M4 (66)	Hand tools and chainsaws
19=	South End	K4 (62)	Chainsaws, hand tools
19=	North End	K1 (61)	Chainsaws, hand tools
21=	Cluster	D (51)	Mulcher or aerial spraying, chainsaws
21=	Track Side	K3 (62)	Chainsaws, hand tools
23	Homestead Spread	E2 (54)	Chainsaws
24	Station Plantings	E1 (53)	Harvesting, chainsaws
25	Stream Zone	K2 (62)	Chainsaws, hand tools, scrub bars
26=	Exotic Plantings	A1 (44)	Harvesting, chainsaws, hand tools, scrub bars
26=	Infill Basin	H (58)	Chainsaws, aerial spraying

The priorities in Table 7 have been assigned to their respective responsible agencies, as identified in Table 6, and are reproduced in Table 8 in order of descending order of priority by organisation. The associated costs and control mechanisms have been reproduced from Table 6. The total costs by agency, assuming all operations are completed, are:- (calculated from Table 8)

- Environment Canterbury \$263,350
- Department of Conservation \$45,000
- Flock Hill Station \$147,000

These costs are based on the assumed control mechanism and are only indicative. They do not take into consideration any other potential source of funding.

Table 8 – Priority ranking (listed in descending order) of Operational Control Blocks by responsible organisation, with collaborating agencies identified where applicable.

Responsible Organisation	Priority	Operational Control Block	Support Agency	Control Mechanism¹	Total Cost^{2,4}
Environment Canterbury (ECan)	1=	Take Off Zone	DOC	C	5000
	1=	Helicopter Hill	DOC	C	5000
	3	Summit Stand		C	3000
	4	Aerial	DOC	S/C	8000
	5=	Northern Pylon Flats	FHS	C	7000
	5=	Southern Pylon Flats		V	100
	7	Cave Stream		V	750
	8	Ski Field Access	DOC	S/C	15,000
	9	Mid Slope		C	30,000
	10	Dense Stand		C	7500
	11=	Western		V	650
	11=	South Face		C	10,000
	13	Back Gully	DOC	S/C	5000
	14	Volunteer		V	350
	15	Scattered Zone		C	20,000
	16	Dense Regeneration		C	20,000
	17=	South End	FHS	C	5000
	17=	North End	FHS	C	1000
	19=	Cluster	FHS	C	25,000
	19=	Track Side	FHS	C	10,000
	21	Stream Zone	FHS	C	15,000
	22	Infill Basin		C	70,000
Department of Conservation (DOC)	1	Western Ridge		C	15,000
	2=	Take Off Zone	ECan	C	5000
	2=	Helicopter Hill	ECan	C	10,000
	4	Aerial	ECan	S	(Time) ³
	5	Ski Field Access	ECan	S/C	15,000
	6	Back Gully	ECan	S	(Time) ³
Flock Hill Station (FHS)	1	Northern Pylon Flats	ECan	S/C	25,000
	2	Flock Hill		C	18,000
	3=	South End	ECan	C	5000
	3=	North End	ECan	S/C	3000
	5=	Cluster	ECan	S/C	10,000
	5=	Track Side	ECan	C	10,000
	7	Homestead Spread		S/C	20,000
	8	Station Plantings		S/C	25,000
	9	Stream Zone	ECan	C	15,000
	10	Exotic Plantings		S/C	16,000

¹Where C = Contractors, S = Staff & V = Volunteers

²For shared operations costs are split according to perceived relative contribution of the involved agencies (which is not necessarily evenly distributed)

³Those operations involving a DOC contribution of staff time only have not been allocated a specific cost to the Department - staff time will be an in-kind support cost

⁴For an explanation of the associated total costs refer to Table 6

16 MAINTENANCE COSTS

This section on maintenance costs has been included in the interests of trying to produce a best estimate of the potential costs involved with completing wilding tree control on Flock Hill Station. The effective control of wilding conifers requires a long-term commitment to conduct ongoing maintenance operations. These need to continue until such time as all source trees and associated spread have been eliminated, or they have been contained to a satisfactory level which can be easily managed for minimal cost and effort.

Estimating maintenance costs is an extremely difficult task. Many variables influence the cost, but of primary concern are the following:-

- Age of trees at the time of the original control operation (determines the presence of any coning trees)
- Thoroughness of previous control operations in terms of effectively killing the target trees
- Length of time between control operations
- The susceptibility of the land to wilding regeneration.

The final point is of considerable concern and is highly variable depending on factors such as land use, soil fertility, climate and browsing pressure. Each site is very different and the amount of regeneration following initial control (assuming the presence of a seed source) is difficult to predict. Some sites may produce carpets of regeneration considerably thicker than the original coverage of wildings, whereas others may produce very little regeneration.

Where an area is very receptive to regeneration, the density of any trees is likely to be very high. However, the associated cost of control can be minimised by conducting control while the trees remain small. Timing of maintenance control operations is therefore critical. It must be conducted before such time as the trees start producing cones, and preferably before they reach a size beyond the practicality of control using hand tools. Even if using other methods of control, such as mechanical mulching or chemical application, smaller trees will reduce overall costs of operations. On the other hand, control should not be attempted too regularly otherwise work will never progress beyond a single patch due to constantly chasing small trees. As discussed in an earlier section, it is recommended that maintenance not be conducted any more frequently than every three years (with the exception of operations involving volunteers and aerial spraying).

Table 9 contains an estimated cost for successive maintenance control operations for each of the identified Operational Control Blocks. For the purposes of generating the figures used, a number of assumptions were made. These include:-

- Areas containing dense regeneration of mature trees were considered to have a high density of subsequent regeneration following initial control due to a high amount of available seed
- Operations involving aerial spraying and volunteers are deemed to cost equivalent amounts for subsequent operations
- No allowance was made for adjusting future control costs to accommodate potential increases, meaning that all figures are based on the current price structure

- All areas containing source trees are initially controlled to reduce the likelihood of reinfestation
- Maintenance control operations are conducted in a timely and effective manner, at the return period identified in Table 6
- A minimum of four maintenance operations will be required in all areas.

Table 9 – Costs for maintenance control operations

Operational Control Block	Maintenance Operation				
	First	Second	Third	Final	TOTAL COST
Bridge Hill					
Exotic Plantings	30,000	10,000	5000	1000	46,000
Summit Stand	3000	3000	1500	1000	8500
Ski Field Access	6000	2000	1000	200	9200
South Face	1500	1000	500	500	3500
Western	650	650	650	650	2600
Pylon Flats					
Northern Pylon Flats	10,000	5000	2500	750	18,250
Southern Pylon Flats	100	100	100	100	400
Cluster	25,000	15,000	10,000	5000	55,000
Northern Lower Slopes					
Station Plantings	8000	1200	800	400	10,400
Homestead Spread	4500	2500	2000	1500	10,500
Upper Slopes					
Flock Hill	5000	3000	1500	1000	10,500
Helicopter Hill	9000	6000	1500	1000	17,500
Back Gully	2500	1200	600	600	4900
Infill Basin	10,000	4500	3000	1000	18,500
Western Ridge	5000	2000	800	400	8200
Mid Slope	10,000	5000	2500	1300	18,800
Western Lower Slopes					
North End	2000	1000	400	200	3600
Stream Zone	9000	3000	1000	500	13,500
Track Side	8000	3000	1000	500	12,500
South End	6000	3000	1200	600	10,800
Cave Stream	750	750	750	750	3000
Flock Hill Stream					
Take Off Zone	4000	2400	1600	800	8800
Scattered Zone	7500	4000	2500	1500	15,500
Dense Stand	7500	7500	4000	2000	21,000
Dense Regeneration	7000	3500	1400	700	12,600
Volunteer	350	350	350	350	1400
Aerial	4600	2300	1200	1200	9300
TOTAL COST	186,950	92,950	49,350	25,500	354,750

The total cost of maintenance for some Operational Control Blocks exceeds the cost of the initial control operation. This is likely to be a factor of having a high density of mature trees at the time of initial control, which results in high potential for regeneration. Some operational techniques also have set costs, regardless of the size and density of trees present. This is particularly the case for operations involving spraying and volunteers.

It is imperative that maintenance operations are conducted. They are necessary in order to ensure that any initial capital investment in control is not lost through allowing infestations to revert back to previous densities. Maintenance costs will dramatically reduce with time provided that it is conducted in accordance with sound wilding tree management principles.

Note that the figures contained in Table 9 are purely speculative and the reality may vary dramatically from the figures presented. As with any control operation of this nature, recalculation of costs needs to be conducted following the completion of a trial using the chosen control methods at the predominant densities and age of regeneration.

17 RECOMMENDATIONS

Flock Hill Station is a unique property within the Castle Hill Basins. The landscape is extremely important and is very vulnerable to change. The ecological values are high with numerous rare plants and plants of local importance occurring on the property. The area is also nationally important to the tangata whenua.

Protecting the integrity of the area by controlling wilding trees is important for conservation purposes as well as maintaining some economic viability as a farm. There are also likely to be longer term economic benefits derived from expansion of existing tourist operations and filming ventures which may well exceed the profitability of farming.

The following recommendations are made:

- Conduct control in accordance with the recommended control blocks, priorities, methods and responsibilities presented in Tables 6, 7 & 8
- Eventual elimination of all trees should be the objective of any control efforts on Flock Hill Station, with the exception of well managed plantings around the buildings and shelter belts of appropriate low spread-risk species. This will effectively remove the need for ongoing wilding control over the property and adjoining areas in perpetuity.
- Encourage a collaborative control effort on Flock Hill Station involving the landowners, land managers, ECan and DOC in accordance with the recommended control blocks and associated priorities. Given the current wilding tree situation on the Flock Hill Station there is likely to be a need for a joint management approach, with certain farming activities being an essential input into the ongoing management of wilding trees on the property. There will have to be a necessary component of compromise between conservation and pastoralism. Without grazing in certain areas the ongoing maintenance costs for tree control would be prohibitive and the initial investment questionable.
- For pastoral lease lands the fundamental requirement regarding wilding conifers is awareness. While land managers are typically becoming more aware of the problem there is an ongoing need for lessees need to be educated on the problem. It is necessary for their to be better collaboration between ECan, DOC and land managers for provision of advise on land management issues relating to the spread of wilding trees. In part fulfilment of this it is recommended that a public day be held for lessees, land managers and interested parties to discuss wilding tree control issues in the high country. This should have multiple speakers to represent different aspects of the issue.
- Where properties contain planted trees that are spreading there should be active management to control this. Where plantings include spread prone species there should be a process for replacement, even though spread in the immediate area is not obvious. This could be just a matter of time or, as is often the case, the spread is not evident in the immediate vicinity due to farm management regimes of

grazing and pasture improvement but wildings may be establishing in areas of less intensive land management downwind of the plantings.

- A 'No Contorta' Policy should be advocated and implemented for the Waimakariri Basin. This would put the emphasis on removal of all planted stands and associated regeneration of lodgepole pine as a land management minimum standard for wilding tree control.
- The University of Canterbury should be actively encouraged to participate in research on Flock Hill Station. This would help address the current lack of long-term pastoral research in the high country, as well as improve the knowledge and understanding of issues relating to the spread of introduced conifers.
- Lobby Central Government for a specific allocation of funding to support a collaborative wilding tree control effort in the Waimakariri Basin. The \$810,000 price associated with completing first stage and maintenance control operations in the immediate vicinity of Flock Hill Station is beyond the current funding capabilities of the agencies involved. Given the crown's intimate involvement with the original source of spreading trees, they should be encouraged to contribute towards control operations.

18 ACKNOWLEDGEMENTS

The completion of this report has taken a considerable amount of time and effort, with a number of individuals having been involved during that period.

Special thanks are made here to Dean Turner and Brian Taylor from the Waimakariri Area Office and Robin Smith from the Mahaanui Area Office of the Department of Conservation for their provision of information relating to the history of spread and Departmental control efforts in the area.

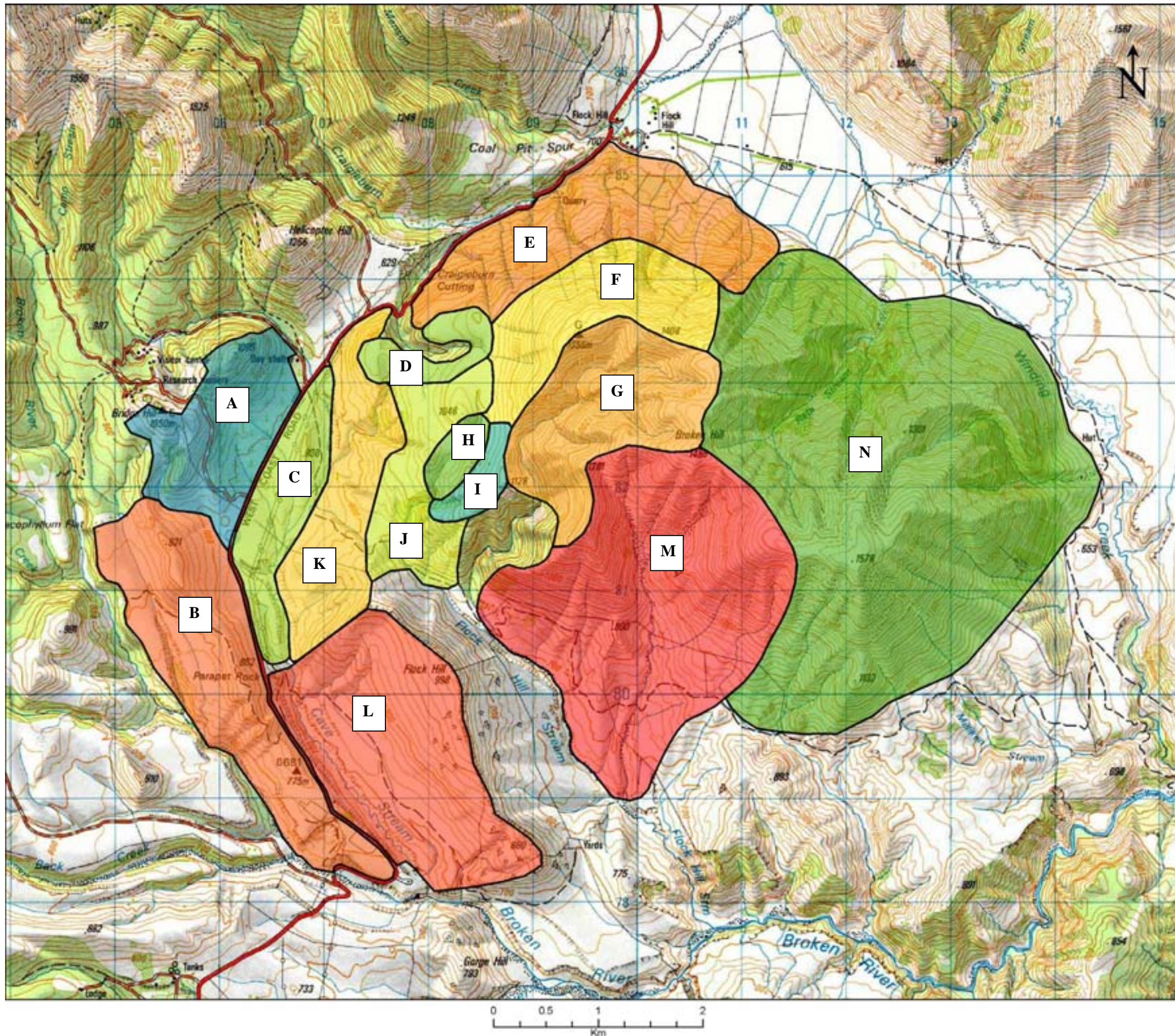
The author is indebted to Nick Ledgard of Ensis for his considerable provision of advice and support for the preparation of this Report. Nick has willingly made himself available to discuss related matters on numerous occasions.

Scott Downs and David Fincham of PF Olsens Limited provided their time to conduct the harvesting inspection at no cost. Their report will be of great assistance with any operational planning.

Finally, thanks are extended to David Hewson of Environment Canterbury for making this report a possibility.

18 REFERENCES

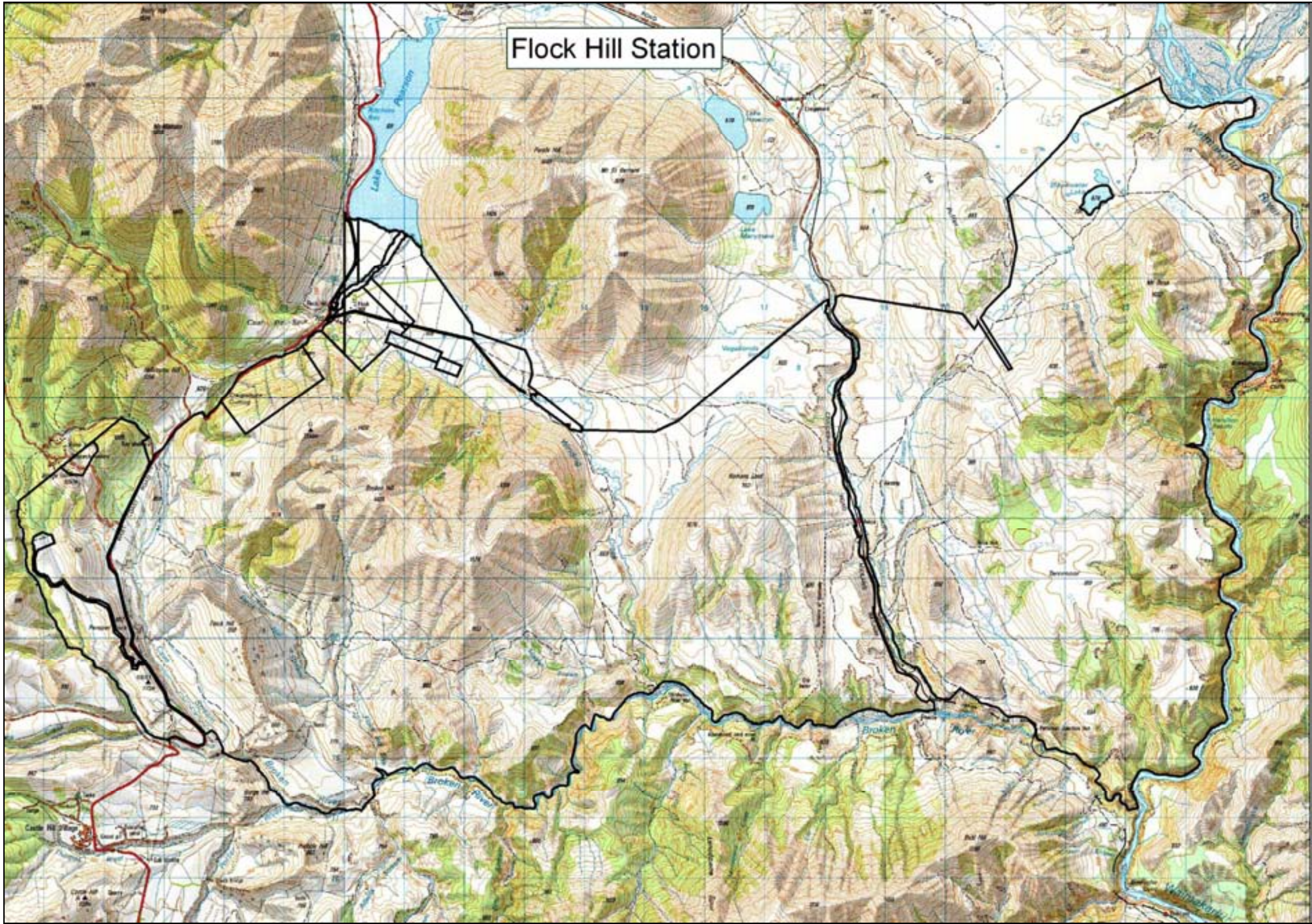
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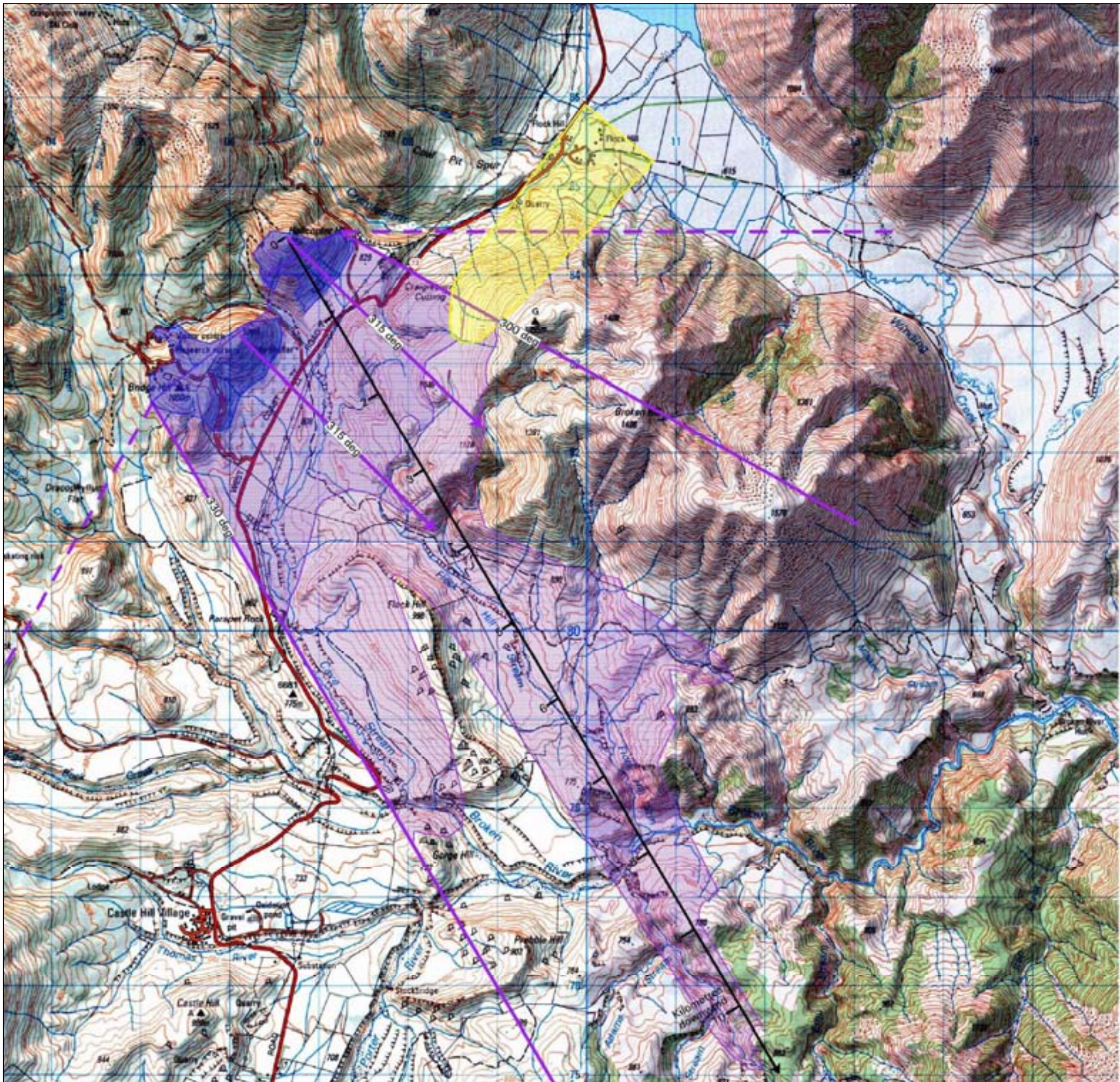
APPENDIX A

Flock Hill Station Control Blocks

- A – Bridge Hill Block (180ha)
Page 44
- B – Western Control Block (326ha)
Page 47
- C – Pylon Flats Control Block (125ha)
Page 48
- D – Cluster Control Block (50ha)
Page 51
- E – Northern Lower Slopes Control Block (265ha)
Page 53
- F – Upper Slopes Control Block (185ha)
Page 55
- G – Back Gully Block (238ha)
Page 57
- H – Infill Basin Control Block (30ha)
Page 58
- I – Western Ridge Control Block (33ha)
Page 59
- J – Mid Slope Control Block (132ha)
Page 60
- K – Western Lower Slopes Control Block (185ha)
Page 61
- L – Cave Stream Control Block (376ha)
Page 63
- M – Flock Hill Stream Control Block (600ha)
Page 64
- N – Aerial Control Block (1150ha)
Page 68




APPENDIX B
Flock Hill Station Map



Legend and notes

 **Source trees**


Pinus contorta on Helicopter Hill planted 1963.
Other spruce-pine species also present.
Bridge Hill planted 1980-1985.

 **Potential seed dispersal on normal velocity wind**

Assuming a common May wind speed of 8 m/s
Expect this dispersal approx. every 4 years
Expect over 95% of seeds to fall in first 0.5 km
Plotted for wind directions 300 to 330 deg


 **Potential seed dispersal on rare high velocity wind**

Assuming 20 m/s wind speed
Expect this dispersal approx. every 15-20 years
Expect over 95% of seeds to fall in first 2.2 km
Plotted for wind directions 300-330 deg

 **Worst case wind direction**

330 deg, carrying seed from Helicopter Hill across SW ridges of Constitution Hill and down Flock Hill Stream to base of Turfosa.

Note that actual long distance spread events in approx. 1977 and 1997 were probably at lesser 315 deg, taking seed from Helicopter Hill to NW slopes of Constitution Hill (in 1977 and 1997) and seed from Bridge Hill down Flock Hill Stream (in 1997).

 **Strong wind directions**

In the months April-May the strongest winds come from the directions 300-330 deg (solid lines). Wind from 270-30 deg is fairly strong (dashed lines).

 **Spread from Flock Hill Station homestead area**

Constitution Hill: modelling the spread of wilding conifers

Heather North (Landcare Research) & Nick Ledgard (Ensis, Scion)
October 2005

APPENDIX D

Harvesting Investigation Report of PF Olsen Limited

Includes covering letter, report and Woodlot Marketing Worksheet
(4 pages)

Explanatory notes for Woodlot Marketing Worksheet:

David Fincham, Harvesting Manager of the Christchurch Branch of PF Olsen Ltd, prepared a harvesting report following an inspection of the area in May 2007. Fincham outlined the findings of the harvesting investigation in the attached covering letter and report. This brief introduction is included to provide some additional information to help clarify the contents of the harvesting report.

The report includes two separate spreadsheets which provide different estimations of potential returns based on the following assumptions:-

- High estimate based on high export log prices, as were experienced when the American currency was stronger earlier in 2007 (positive return)
- Low estimate based on the considerably lower export log prices prevailing in May 2007 (negative return)

Note that the value of the New Zealand currency at the time of publishing has forced export log prices even lower than the May valuation. Potential returns will be strongly influenced by world currency markets (with the exception of *Pinus nigra* as explained in the report).

Each spreadsheet calculated costs and potential returns for the identified species according to various grades of log, point of sale, and unit of sale. The following identifies some of the key acronyms used in the report:-

- S/L – saw log
- Exp – export
- K(T), A, KI – different grades of export log
- am – at mill
- awg – at wharf gate
- t – tonnes
- j – short for JAS (Japanese Agricultural Standard), a measurement convention for export grade logs

It is important to reiterate that the figures contained in the report are estimates only and are based on a rudimentary inspection conducted for the purpose of determining harvesting potential. This has concluded that harvesting is worth considering but would need to coincide with stronger export log prices. A more thorough investigation would be necessary to produce more accurate results. This would include mapping to quantify the amount of resource and the measurement of a sample of trees for size and quality of timber.

22 05 07

Darrin Woods
PO Box 146
Lincoln
CHRISTCHURCH

Dear Darrin

This brief report follows on from a request made by Dean Turner from Department of Conservation based at Rangiora. He asked that we follow up on the work Karl Mullan and yourself had started early in 2006 to provide some estimates of the potential value from harvesting several exotic tree stands in or near the Craigieburn Forest Park.

The report is based on a quick visual inspection of the area and trees on the 3rd of May 2007.


The inspection was made by Scott Downs and David Fincham from PF Olsen Ltd and yourself.

The costs and net revenue figures contained in the report are at this stage estimates only, but should be enough to give the reader a feel for the potential value these stands may have.

We feel there is potential in the Bridge Hill block if harvesting can be planned to co-incide with high export log prices. The prices at present are close to the low figures on the attached Woodlot Marketing Worksheets and would probably not produce a positive net return apart from the P nigra which is not affect by the export price. We expect export log prices to pick up again in the 4th quarter of this year at which time a completely different out come may be expected. If the harvesting of these stands were done in conjunction with the DOC stands, then saving could be made due to the larger scale of the operation.

If there is anything in the report that you would like clarification or further information on please contact either Scott Downs or myself

Yours faithfully
PF OLSEN LTD


David Fincham
Harvesting Manager

WAIMAKARIRI BASIN HARVEST INSPECTION

Bridge Hill

This block has semi mature P.ponderosa, Larch and Dfir which should be able to be harvested without too much difficulty in dry conditions. We have provided a rough estimate of costs and revenues for the P.ponderosa, Larch and Dfir. There will be markets available for all these species, but timing will be crucial if a positive return is to be achieved. The costing provided show that at the high export log prices which were achieved earlier this year a positive return of around \$1,600 per hectare for the P pon is possible, and up to \$17,000 per hectare for the Dfir and \$14,000 per hectare for the larch. The estimates show that at low export prices all species would show a negative return by between \$2,000 and \$5,000 per hectare.

As we did not see the P nigra we have not provided any estimates of possible return but as these are not reliant on the export markets and the domestic market for post and poles is reasonably steady and the fact that P.nigra is keenly sort after, this stand should produce a good return per hectare.

To produce more accurate figures on potential harvest returns we would need to quantify the resources by species. To do this we would need to get a current aerial photography from which we could produce stand maps. We would also need to establish plots through the stands to determine volumes.

The cost to do these would be approx \$3,000-\$4,000. We could provide a quote for this work if required

