5 WEEDS

5.1 Challenges

Weed invasion is generally the major cause of failure of revegetation programs in Australia. Morevoer, one of the major challenges associated with restoration of pine sites, or sites in the vicinity of pine plantations, is the control of self-sown pines (often referred to as 'wildlings'). In Australia, *Pinus radiata* wildlings are a major weed of pine plantations and adjacent areas (Richardson and Higgins 1998; Lindenmayer and McCarthy 2001). The success of *Pinus radiata* as an invasive species is related to a suite of features that facilitate dispersal including life history traits, extent of planting, and the disturbance regimes of surrounding environments (Table 5.1). Where plantations are located in environments conducive to spread (e.g. areas with little ground cover) pine wildling invasion can be prolific (Figure 5.1).

Due to the significance of the pine wildling issue within former pine sites and the lack of readily accessible information, the discussion of weeds focuses on pine wildlings with some introductory comments on blackberry, one of the other significant weed species within pine plantations. The remainder of this section focuses on features that dictate the spread of pine wildlings and control measures that have been used within rehabilitation projects. The final section deals with blackberry, specifically dispersal and control methods.

Figure 5.1 Pine wildlings invading a fragmented forest adjacent to a logged compartment within the Delatite Plantation in NE Victoria

Table 5.1 Major factors determining the degree of invasiability of pine species in the Southern Hemisphere

(modified from Richardson et al 1994) Each of the facilitating features are displayed by *Pinus radiata*

Factors	Facilitating feature(s)	Limiting feature(s)
Species attributes		
Seed mass	Small seeds with large wings	Large seeds with small wings
Juvenile period	Short (<10 years)	Long (>10 years)
Interval between large seed crops	Short (<3 years)	Long (>5 years)
Ability to survive moderate browsing levels	Good	Poor
Residence time	Long (> 50 years)	Short (<50 years)
Extent of planting		
Total area	Large	Small
Boundary: total area ratio	Large	Small
Ground-cover characteristics		
Basic vegetation structure	Bare of sparsely vegetated ground, shrubland, grassland	Forest
Vegetation cover	None-low (<50%)	High (>80%)
Distance from the equator	Latitude: 30-45ºS	Latitude: <30ºS
Disturbance		
Frequency	Low-moderate	Very low/very high
Human-induced types	Moderately increased herbivore pressure (grazing, browsing, trampling) or equivalent	Great increased or greatly reduced herbivore pressure of equivalent
Contributing factor	Decreased competition from ground-cover	Increased competition from ground-cover or physical elimination of pine (e.g. by mechanical clearing)
Natural types	Slope instability, wind, flooding, fires from volcanoes	Frequent fires (e.g. in grasslands)
Resident biota		
Composition of plant community	Naturally invadable community	Naturally resistant community (e.g. *Eucalyptus blakelyi* forest in NE Victoria)
Indicators of invadability	Conditions unsuitable for C4 photosynthetic pathway and nutrient-poor soils: paucity of vigorous herbs	Conditions suitable for C4 photosynthetic pathway and nutrient-rich soils: abundance of vigorous herbs
Role of mammals other than humans	Removal of competing vegetation (e.g. through grazing) Dispersing pine seeds (birds and mammals)	Destroying pine wildlings (browsing, trampling)
Role of fungi	Presence of appropriate mycorrhizal symbionts	Absence of mycorrhizal symbionts (no longer limiting?) Influence of pathogenic fungi

5.2 Extent of pine wildlings

Within a plantation setting, the extent of the pine wildling problem is strongly related to:

- the natural environment (e.g. type of native vegetation, soil seed store, soil type);
- the pine plantation (e.g. species of pine, age structure of plantation); and
- the rehabilitation method - that may either reduce or exacerbate the pine wildling problem.

5.2.1 The natural environment

Where the surrounding native vegetation supports a dense cover of ground or understorey species, there will be limited opportunity for pine wildlings to spread into surrounding forests due to the limited availability of resources through competition (e.g. for light, space). Areas that are generally undisturbed up until plantation establishment frequently regenerate rapidly through the germination of soil stored seed whilst areas with a long agricultural history provide few opportunities for natural regeneration of native species. Where plantations were established within marginal sites, unfavourable conditions (e.g. climate) may limit the growth and survival of pines. At higher altitudes increased rainfall may accelerate the decomposition of pine seed whilst favouring the regeneration of native species.

5.2.2 The pine plantation

The size, age and species composition of a pine plantation contributes to the extent of the pine wildling problem. A large sexually mature pine plantation will provide a large source of pine seed while individual pines or small strips of pines left behind following harvesting activities will provide a substantially smaller supply of pine seeds. The species composition of a plantation will determine the age at which trees reach sexual maturity and the type of seed produced that dictates dispersal distances.

The amount of slash left on a site will have a bearing on the type of site preparation (e.g. fire) and revegetation techniques that can be used, and in turn, the extent of the pine wildling problem within a treated site (see section 4). For example, a high intensity broadcast fire will kill pine seed and create a suitable seedbed for regeneration purposes further limiting wildling regeneration through competition with native species. In contrast, low slash loads will result in a low intensity burn that may not kill pine seed nor produce a receptive seedbed for native species.

The proximity of a harvested site to the surrounding pine plantation (or other commercial interests) will also have an effect on the pine wildling problem by limiting the type of pine wildling control and rehabilitation techniques that can be used. Any adjacent pine plantations will provide an ongoing source of pine seed until harvesting is completed. Moreover, where a pine plantation spans a number of age classes, the younger age class will provide an ongoing source of pine seeds for possibly many years into the future.

5.2.3 Rehabilitation techniques

Site preparation and revegetation techniques affect the extent of the pine wildling problem by:

- killing pine seed and pine wildlings (e.g. by fire);
- accelerating the regeneration of native species – through the provision of a suitable seed bed and by triggering the germination of soil stored seed (e.g. by fire); and
- providing opportunities for the regeneration of pine wildlings by creating receptive seed beds and a reduction in competition from other species (e.g. low intensity fires, removal of other species), this situation typically follows if a site has been harvested and subsequently left untreated.

5.3 Pine wildling control

Pine wildling control techniques used across the range of locations include manual methods (e.g. hand pulling, machetes, brush cutters, chainsaws), fire, herbicides and heavy machinery (e.g. scalping). Fire is the most successful pine wildling control technique across the range of sites in eastern Australia, especially in situations where fire has not only killed pine seed and pine wildlings, but also promoted the germination of soil stored seed or introduced seed. In situations where there is dense regeneration of native species the germination and establishment of any remaining or introduced pine seed is generally restricted through competition.

There are some constraints associated with the use of fire that need to be assessed on a site by site basis:

- 'cool burns' are of an insufficient intensity to kill larger pines (see Figure 5.2)
- fire will not burn evenly across a site;
- control burns represent an increase in fire frequency that may be detrimental to native species;
- fire may lead to soil and nutrient losses;
- surrounding commercial interest may be at risk; and
- ineffective use of fire not only limits the success of pine wildling control, but may also affect the regeneration of native species (e.g. by killing soil stored seeds).

Manual methods or herbicides (e.g. stem injection) can compliment the use of fire where fires have burnt unevenly or are of an insufficient intensity to kill all pine wildlings. This was typically the practice at Kosciuszko National Park where large pines were cut down or sprayed with herbicides with the subsequent application of fire to kill small pines and residual seed.

Pine wildling density and size are an important determinant of methods used to control pine wildlings. Large pines at low densities and some distance from the plantation or situated within native forest are best treated with manual methods or stem injection, while small wildlings at high densities can be treated with fire, sprayed or removed by manual methods.

The strong regenerative capacity of pines dictates that any pine wildling control techniques must be implemented correctly. Young pines have flexible stems, and techniques that aim to push pines over (e.g. using the blade of a bulldozer) generally have low rates of success due to the capacity of the pines to bend rather than break and subsequently 'spring back'. Pines are capably of regenerating from lateral branches and must be removed from below the first lateral branch to be successful. Stems must be fully cut and separated to ensure death of the plant as there have been cases (although remote) where partial contact of severed stems have allowed the tree to survive. Removal of pines by hand pulling must ensure that the entire plant and root system is removed from the ground and any application of herbicides must be monitored with follow-up treatment as necessary.

Case study – the control of pine wildlings within a plantation of *Pinus radiata* in Western Australia

Fire has been used to control pine wildlings as *Pinus radiata* does not have the capacity to resprout from vegetative buds (Burrows et al. 1989; Gill and Williams 1996). Burrows et al. (1989) investigated the use of low intensity fire to kill wildlings in a *Pinus radiata* plantation in Western Australia and found that a fire intensity of about 200 kW m^{-1} scorched the canopy to a height of 8 m, killing most plants up to 10 m tall. An intensity range of 100-200 kW m^{-1} was considered controllable and was unlikely to damage mature pine, while killing most wildlings less than 5 m tall (Burrows et al. 1989). This intensity range was achieved with a fuel load of 12 t ha^{-1} of course fuel (> 10 mm in diameter) and 2 t ha^{-1} of fine fuel (Burrows et al. 1989). Burrows et al. (1989) recommended that burning should be restricted to plantations greater than 15 years old as younger trees would be vulnerable to crown and bole damage. Conversely, a thicker bark and greater distance between the ground and the fuel bed makes the older trees more resistant to fire damage.

Figure 5.2 Case study – the use of fire to control pine wildlings in Western Australia

5.3.1 Recommendations

From the above discussion of pine wildlings it becomes clear that there are a large number of variables that affect both the extent of the pine wildling problem and the most suitable technique(s) for any particular location.

Several factors need to be taken into consideration prior to implementing any pine wildling control technique, namely:

- size of the area;
- pine wildling density;
- size of pine wildlings;
- pine species (e.g. capacity for seed dispersal);
- age (to reach sexual maturity);
- type of area requiring control (e.g. within harvested coupes, surrounding native vegetation);
- fuel load (that in turn dictates fire intensity);
- environmental constraints (e.g. water quality issues, significant fauna/flora species);
- surrounding environment (e.g. plantation, native forest, farmland);
- resources (e.g. funding, staff, expertise, volunteers); and
- source of pine seed (e.g. surrounding mature pines, second rotation pines, individual trees).

Early treatment of pine wildlings is critical as it will limit the extent of the pine wildling problem in future years and ultimately reduce the amount of resources required for long-term pine wildling control. It is critical to remove pine wildlings before they reach sexual maturity and become an additional seed source that further exacerbates the problem. Wildlings within remnant vegetation and adjacent to plantation areas should be treated as a matter of priority. These areas have the potential to provide propagules for regeneration of native species, and as wildlife habitat and corridors for fauna, that may in turn act as vectors for dispersal of native species.

5.3.2 Monitoring pine wildling control operations

The importance of monitoring contracts was outlined in section 3.3 and its inclusion here within the context of pine wildlings serves as a reminder of the importance of monitoring operations and further, to the strong regeneration properties of pines that demand appropriate and correctly applied control operations.

5.4 Blackberry

Blackberry (*Rubus fruiticosus* spp. agg.) is a significant weed within pine plantations (Figure 5.2). The recurrent high intensity disturbance that is associated with logging activities provides ideal conditions for the growth and invasion of blackberry (Lindenmayer and McCarthy 2001). Few plants can compete with blackberry due to its rapid growth rate and dense canopy that seriously impeded the regeneration of native species (Parsons and Cuthbertson 2001). Blackberry rarely invades undisturbed forest (Parsons and Cuthbertson 2001), however Lindenmayer and McCarthy (2001) found that blackberry forms dense thickets at the eucalypt/pine forest edge, providing a readily available source of seeds for invasion into eucalypt forests, with thickets most common in wetter sites.

Blackberry can disperse by seed, root suckers, root fragments and by tip-rooting where the trailing first-year stems take root at the tip in touch with the ground, eventually forming a new plant independent from the parent bush.

Control techniques include physical removal of the crown and root system by mattocking, cultivation, or bulldozing and ripping roots – techniques that may be suitable for isolated and relatively small infestations, but are rarely practical for most situations (Parsons and Cuthbertson 2001). Slashing or burning only provides temporary control with extensive regrowth from the crown and lateral roots. Goats are an effective means of controlling blackberry as they readily eat the plant and prefer blackberry ahead of several pasture species, however they incur additional costs associated with fencing and animal welfare (see Parsons and Cuthbertson 2001).

The most effective means of blackberry control is repeated application of herbicides (see Parsons and Cuthbertson 2001). Effective herbicide control requires sufficient leaf material to allow the chemicals to be absorbed by the plant. Following widlfire, burning operations or logging activities, little aboveground growth remains, making herbicide application unviable with several years of regrowth required in order to provide sufficient leaf area for herbicide use to be effective. Such difficulties are currently being experienced within the extensive areas of pine plantations burnt in the wildfires that swept through Canberra in January 2003.

The timing of blackberry control is essential. Ideally blackberries should be controlled before any logging operations, soil disturbance or burning operations as there is generally insufficient leaf area for effective absorption of herbicides following these activities. Herbicide control should also be conducted before revegetation activites commence in order to avoid the death of non-target species.

Figure 5.3 Blackberry infestation (foreground) within a harvested pine plantation at the Delatite