The challenges of controlling an extensive radiata pine (*Pinus radiata*) infestation in native bushland

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Summary The Tasmanian Land Conservancy developed and implemented a project to control a large radiata pine infestation in native bushland on Bruny Island, southern Tasmania, in 2013.

Primary control of the radiata pine infestation was achieved by combining two methods: felling of small individuals below the first branch, and drill and kill of larger individuals using undiluted glyphosate 540 g a.i. L^{-1}. Using a drill and kill technique developed in New Zealand, the number of holes required per tree to achieve a complete kill was approximately one hole per 35 cm of tree circumference, with 10 mL of herbicide injected into each hole.

The development of the project was challenged by a lack of information on control methods suitable for use in native bushland, where off-target impacts, including soil and vegetation disturbance were required to be minimal. Further challenges were also faced regarding regulatory and social issues. These challenges were successfully negotiated, resulting in a high success rate in the primary control of radiata pines within regulatory guidelines and in a manner acceptable to the community.

Keywords *Pinus radiata*, weed control, bushland, glyphosate.

INTRODUCTION

The Tasmanian Land Conservancy developed and implemented a project to control a large radiata pine (*Pinus radiata* D.Don) infestation that occurred in otherwise good condition native bushland on Bruny Island, southern Tasmania, in 2013. The privately owned, 371 hectare property is managed for conservation and recreation, and the property supports extensive native vegetation, including habitat for numerous threatened plant and animal species. Estimates placed the radiata pine population at approximately 80,000 individuals, with most of these occurring as small mature trees in high densities within Eucalypt woodland. The aim of the project was to control radiata pines at the site to enhance its conservation values and improve the scenic amenity of the property.

Radiata pine is a significant weed species in Tasmania, but is also a significant economic species for the timber industry. Methods used in Tasmania for the control of radiata pines are focused around the felling of large numbers of immature individuals and the mechanical felling of large numbers of mature individuals where vehicle access is uninhibited. No examples of weed control projects in Tasmania or south-east Australia that targeted large infestations of mature radiata pines in undisturbed bushland were identified.

With a lack of published information on large-scale radiata pine control methods, advice was sought from weed practitioners in Tasmania, Victoria and New Zealand. Numerous control methods were considered, taking into account the size and extent of the project, the very good condition of the bushland in which the radiata pine infestation occurred, the lack of vehicle access throughout most of the site, the anticipated cost of the control method (including the likely number of layover days due to poor weather) and the likely success rate.

Off-target herbicide impacts were to be kept to a minimum to protect threatened plant species and threatened animal habitat. Physical disturbance was also required to be minimal to prevent any further weed and/or disease introductions. Bushfire fuel load was also of concern to the landowner.

Several control methods were considered, including felling, drill and kill (or stem/herbicide injection) and ring barking.

Felling of large trees was discounted due to the physical impact that falling trees would have on the surrounding native vegetation, and the effect that large dead trees on the ground would contribute to increased bushfire fuel load, and decreased accessibility for follow-up weed control. Other Tasmanian projects have felled radiata pines and removed these using machinery to minimize bushfire fuel load and increase accessibility for follow-up weed control, however these projects were undertaken on heavily disturbed sites that were formerly radiata pine plantations (e.g. Bushways Environmental Service 2009).

Ring barking was also discounted, with results from New Zealand studies showing the method to be slow to kill trees and unreliable, with only a 60% kill rate after three years (Raal 2005).

Developed and described by various groups in New Zealand, including the Marlborough Sounds

Restoration Trust (Marlborough Sounds Restoration Trust, 2013) and the Department of Conservation (Raal 2005), the drill-and-kill methodology, applies herbicide directly into holes drilled into the tree trunk. The Marlborough Sounds Restoration Trust (2013) and Raal (2005) noted that radiata pines treated using this method die quickly (usually within 3–6 months), but break down gradually over 10–15 years, minimising damage to the surrounding vegetation, which is particularly advantageous when the aim of control is to encourage native forest regeneration. The drill and kill method is also often considered more acceptable than other chemical control methods, such as spraying, as herbicide injection means all herbicide is contained within the tree, with no discharge into the air, waterways or onto land, and no effects on non-target trees nearby.

Tasmania currently require landowners to obtain approval under the Forest Practices Regulations 2007 for clearing of trees across an area >1 ha or totaling >100 tonnes timber. These laws are to prevent indiscriminate clearing of forest, however also include projects such as this one, seeking to remove an environmental weed trees from native forest. Under advice from the Forest Practices Authority, it was determined that a Forest Practices Plan was required for this project, which brings with it additional regulations and costs.

SITE DESCRIPTION

The project was located on private property near Cloudy Bay, South Bruny Island, Tasmania, approximately 80 km south of Hobart, at latitude 43.42°S. The site has a cool temperate, maritime climate, with average annual rainfall of 945 mm occurring throughout all months of the year. The soils vary from heavy clay to grey sands, typical of the underlying Jurassic dolerite geology.

MATERIALS AND METHODS

Primary weed control works were undertaken when radiata pine was actively growing, starting November 2013 and completed by early May 2014.

Two complementary methods were used for achieving primary control of the radiata pine infestation, both of which could be undertaken in inclement weather.

Felling of small trees Small individual trees <10 cm diameter at breast height (DBH) were felled below the first branch, using a brush cutter with a circular saw blade, or hand-held loppers. Felled trees were left in situ to break down over time. No herbicide was used on the stumps, as radiata pine does not continue to grow if the plant is felled below the point of any green foliage.

Drill and kill of trees Larger individual trees >10 cm DBH were drilled and killed using undiluted glyphosate 540 g a.i. L^{-1}, using a technique developed in New Zealand (see Marlborough Sounds Restoration Trust 2013).

Holes were drilled using a petrol powered drill, using an 18–20 mm auger bit, at even spacings into the sap wood of the tree trunk no more than 35 cm apart. Holes were drilled at a convenient height, angled downwards at approximately 45° to a depth of approximately 75 mm.

Immediately after drilling, each hole was filled with 10 mL of undiluted glyphosate 540 g a.i. L^{-1}, using a calibrated animal vaccinating (drenching) gun. Where the high viscosity of glyphosate was problematic with the injection tools being used, it was weakly diluted with water, at a rate of no more than four parts glyphosate to one part water.

When a tree had multiple leaders or stems, each leader or stem was treated as a separate tree.

Contractors undertaking the drill and kill project worked in pairs, with one person drilling being closely followed by another person administering the herbicide and marking treated trees.

Quality assessment of the weed control works was undertaken on an opportunistic basis throughout the project, with individual trees measured for DBH, number of holes drilled and % die back of foliage. These trees were marked and re-visited until tree mortality had occurred (this is observed as 100% browning of foliage).

RESULTS

Approximately 12,500 individual radiata pine trees were treated with the drill and kill method, and an estimated 70,000 individuals were felled.

Monitoring occurred on 48 individual trees that had been treated with the drill and kill method. These trees ranged in size from 9–60 cm DBH, with an average of 26 cm DBH. Monitoring of felled trees was not assessed, due to insufficient time for regrowth to occur between felling and the end of this study.

Mortality rates of pines treated with the drill and kill method within 152 days of treatment were high.

Browning of foliage in treated trees was evident within 28 days of treatment. Complete browning of foliage had occurred in 90% of treated trees within 104 days of treatment, and in 95% of trees within 152 days of treatment (Table 1). At 152 days post-treatment, the remaining 5% of trees were observed to have 95% browning of foliage and were expected to fully die.

Smaller trees appear to die faster than larger trees, although this trend was not statistically significant (see Table 1).

Browning of foliage on herbicide treated trees was also observed to occur faster than on those trees that were felled, although no data was collected.

Costs of drill and kill control method For this project, a four-person crew working in pairs treated on average 812 trees per long work day (10+ hours), drilling an average of 3.4 holes per tree. However, this work rate varied dramatically with tree size, tree density and terrain. Using the total number of trees treated and the number of person/days spent drilling and killing, herbicide cost was $0.31 per tree and labour cost was $1.97 per tree (at $50 per person per hour). Importantly there were no days lost to inclement weather, due to the pine control method used.

Costs of felling small trees The cost of felling small trees varied greatly dependent upon terrain, surrounding vegetation type and density, diameter of the trees and the density of the pine infestation. Costs for this project have been estimated to vary between $75 and $300 ha^{-1}, with the lower rate in areas that were open woodland (i.e. easy to walk around with high visibility) with many tall radiata pine saplings (i.e. fast to fell and fast to move between radiata pines). The higher rate was typical of dense scrub or heath (i.e. difficult to walk around with low visibility) with low numbers of radiata pines. In these situations significantly more time was spent searching for individuals than felling them.

Off-target impacts Off-target impacts were negligible, with limited impacts observed to threatened plant species and threatened animal habitat. These impacts were limited to breaking of shrub branches, caused by falling tall pines with a DBH <10 cm.

Bushfire fuel loads were assessed before and after radiata pine control, by estimating volume of fine fuels at surface and elevated fuel levels using the Overall Fuel Hazard Assessment Guide (Hines 2010). Bushfire fuel loads were slightly increased due to the felling of small trees and the addition of leaf litter from decaying pines. However, these changes to the fuel loads did not change the fuel hazards present at the site after the pine control works, due to the density and continuity of the native vegetation at both the surface and elevated fuel levels.

Impacts on recreational use were minimal, with a slight disruption on areas accessible for recreation during the control works. Trees treated with herbicide will be assessed annually for safety, with unsafe trees being felled.

Table 1. Mortality rate of sampled radiata pines post-treatment (n = 48) and average size of trees.

No. of days post treatment	Mortality rate of pine population %	Av. DBH
48	2.08	13
75	35.42	21
95	54.17	30
104	89.58	30
152	95.00	31

DISCUSSION

This weed control project achieved its aims, achieving a rapid and consistently high mortality rate, with few off-target impacts. The control of radiata pines will result in the improved condition of habitat for threatened species present on the property, as well as improving the scenic amenity of the property.

The development of the project encountered numerous challenges, which may prevent projects of a similar scale from being repeated by other groups, if these are not taken into account early in the project development stage. These challenges included a lack of permits allowing either the dosage and/or concentration of the most effective herbicides as required by the drill and kill method, and the legislated requirement in Tasmania requiring landowners obtain approval for clearing or felling of trees over an area >1 ha.

Herbicide efficacy and approval for use The specific drill-and-kill methodology used for this project was developed by various groups in New Zealand. These groups recommend the use of either undiluted glyphosate 540 g a.i. L^{-1} at a dosage rate of 10 mL per hole, or metsulfuron methyl diluted to 50 g L^{-1} at a dosage rate of 10 mL per hole. Metsulfuron methyl is the preferred option, being cheaper and more effective on large trees (>60 cm DBH). At the start of this project, neither of these herbicides was approved for the required use on the herbicide label or an existing off-label permit. Discussions with Tasmania's chemical registrar indicated that varying the current off-label permit for the use of undiluted glyphosate 540 g a.i. L^{-1} from a maximum dosage rate of 2 mL per hole to 10 mL per hole would be acceptable, given a South Australian permit that already allowed this dosage and dilution rate. A request to vary the off-label permit for glyphosate was approved in 2013 (APVMA 2013).

Where future radiata pine control projects are aiming to treat predominantly large trees, the use of the relatively low cost herbicide metsulfuron methyl should be trialed in partnership with the APVMA or relevant state department, as an alternative to the less effective and more expensive glyphosate 540 g a.i. L^{-1}.

Regulatory challenges The requirement by the Forest Practices Regulations 2007 to obtain a Forest Practices Plan placed additional cost and time pressures on this project. Future Tasmanian projects of a similar scale should work closely with the Forest Practices Authority from the outset of the project, and seek an exemption from these regulations.

CONCLUSION

Despite the extensive challenges in developing this project, it has been highly successful, with an excellent control rate occurring within regulatory guidelines, and within the parameters set by the landowner.

ACKNOWLEDGMENTS

The author acknowledges the high standard of on-ground works by Woodstock Forest Services; advice on the drill and kill technique from Andrew Macalister, Marlborough Sounds Restoration Trust, and Pete Raal, Department of Conservation, New Zealand, and general support for the project from volunteer Mathew Bartlett and project officer, Tim Ackroyd. Thanks also go to the landowner for undertaking the project, despite the many challenges faced during its development.

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