Controlling desert ash (*Fraxinus angustifolia* subsp. *angustifolia*): have we found the silver bullet?

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Summary Desert ash (*Fraxinus angustifolia* Vahl. subsp. *angustifolia*, Oleaceae) is a weedy deciduous tree in south-eastern Australia, particularly in riparian situations. It reproduces by seed and by root suckers and can form monocultures displacing desirable native shrubs and trees. Very little published information is available regarding suitable control methods and anecdotal reports of the effectiveness of herbicides are variable. We conducted two trials to determine the effectiveness of herbicides to control desert ash. From the first screening trial picloram and triclopyr + picloram were excluded, and the herbicides glyphosate, glyphosate + metsulfuron-methyl, metsulfuron-methyl alone at two rates and triclopyr ester were tested further. Approximately 150 trees were used in a second trial with herbicide treatments applied using the cut and paint method. Glyphosate was the best performing herbicide, with no healthy regrowth arising from stumps at the end of the trial, 35 months after treatment (MAT). Triclopyr ester also performed well with regrowth from 6% of treated stumps. The number of stumps with regrowth for the two metsulfuron-methyl treatments and the metsulfuron + glyphosate mix increased over the three year period of the trial, while the number of stumps with regrowth reduced for the glyphosate and triclopyr-treated stumps. Trials are underway to determine the effect of herbicide application method (cut stump, stem injection) and time of application (winter, summer, autumn) on desert ash control.

Keywords Herbicide, glyphosate, metsulfuron-methyl, triclopyr, picloram.

INTRODUCTION

Desert ash is a deciduous tree native to south and eastern Europe (Spencer 2002). It is a weedy tree that is of particular concern in riparian areas and along drainage lines in Australia. Desert ash out-competes native plants for moisture, light and nutrients and can take over the vegetation in natural areas. Over time it forms dense monocultures, spreading via suckers and preventing the regeneration of native species (Muyt 1999). It is regarded as an environmental weed in Victoria, South Australia, Australian Capital Territory and New South Wales (Blood 2001), and is also recorded from Western Australia and Tasmania (CHAH 2014). The largest infestations are currently located around Melbourne, central Victoria and Adelaide. It produces many single seeded winged fruit (samara) which spread from ornamental or streetscape plantings into creeks and river systems, wetlands, urban bushland, lowland grasslands and grassy woodlands. It is typical to find a stand or row of desert ash planted along a driveway, beside a road or street at the upstream end of an infestation along a watercourse (author's observations).

Very little published information is available regarding suitable control methods, and anecdotal reports from management agencies of the effectiveness of single applications of herbicide are variable, with follow up applications often required (Mark Scida (Melbourne Water) and Colin Tate (Goulburn Broken Catchment Management Authority) pers. comm.). The Department of Environment and Primary Industries in conjunction with Melbourne Water and Goulburn Broken Catchment Authority have been conducting trials examining potential herbicide choices and, more recently, treatment methods and timing of application in an attempt to maximise control effectiveness and efficiency.

An initial herbicide screening trial at Musk Creek, Modella tested five herbicides: metsulfuron-methyl, glyphosate (aquatic formulation), a commercial picloram/triclopyr mix (amine salt), triclopyr (ester) and picloram (potassium salt). A control (water) treatment was included, and each treatment comprised six trees as replicates. Regrowth was observed in all treatments with metsulfuron-methyl and glyphosate being the most effective (regrowth of one and three trees, respectively). All six trees (100%) in picloram and control treatments recovered. These results guided a second trial at Emu Creek, Clarkefield, where a subset of herbicides from the first trial, either alone or in combination, was tested on a larger number of trees. This report examines the long-term outcome of the second trial and the implications for operational activities including herbicide selection.

Table 1. List of selected herbicides and application rates. Note: not all of these herbicides are registered for this use; this trial was undertaken under APVMA Small-scale Trial Permit PER7250.

Herbicide	Treatment abbreviation	Tank mix
Metsulfuron-methyl (600 g kg^{-1})	M-Lo	10 g to 100 L water
Metsulfuron-methyl (600 g kg^{-1})	M-Hi	10 g to 10 L water
Metsulfuron-methyl (600 g kg^{-1}) + glyphosate (360 g L^{-1}), aquatic area formulation	MG	(1.5 g metsulfuron-methyl + 1 L glyphosate) to 1.5 L water
Glyphosate (360 g L^{-1}), aquatic area formulation	G	Undiluted
Triclopyr butoxyethyl ester 600 g L^{-1}	T	5 L concentrate to 60 L diesel

FIELD SITE AND METHODS

The trial site chosen was Emu Creek at Konagaderra Road, Clarkefield (37°30.270' S, 144°45.990' E) northwest of Melbourne, Australia. This creek has unimproved cattle pasture on each side and is fenced by a single electric wire. Occasionally cattle gain access and kangaroos are frequently observed inside the fenced area.

As with many tree species, *Fraxinus* L. is a genus known to produce intraspecific root grafts (La Rue 1934, Graham and Bormann 1966), which may allow for herbicide translocation between trees and interfere with treatment outcomes. Damage to adjacent trees due to the translocation of herbicide between trees where natural root grafts are present is known to occur in herbicides from the auxin-mimic group (the phenoxy acids, e.g. 2,4-D, picloram, triclopyr), but has not been recorded for other herbicide classes.

To avoid the potential for herbicide cross-contamination between trees, clusters of desert ash trees of various basal diameters (i.e. age class independent) were circumscribed along a 1.5 km reach of the creek. The physical size of the cluster and number of trees within it were dictated by the natural positioning of trees along the creek. However, all clusters had a minimum distance of 6 m between them (median = 16 m; max = 267 m). A total of 46 clusters comprising 1 to 15 trees, were blocked and randomly assigned to one of five treatments (herbicides). Random allocation was repeated until tree counts between clusters were approximately equal (Table 2).

Working downstream, herbicide was applied by the cut-stump method to all trees between 5 and 8 April 2011 (late autumn), inclusive. At that time trees were beginning to show the first signs of winter dormancy when leaf yellowing was observed; however, most trees retained close to a full leaf canopy. Individual trees were felled, after which the stump was clean cut as near to the ground as safely possible. Within 30 seconds the cut surface of the stump was irrigated with a selected herbicide and distributed evenly using a paint brush. Brushes were unique to each treatment to eliminate contamination. A total of 152 trees were treated. Average basal diameter was 19 cm (SD 12.0 cm). Summary information of treatments, clusters and tree numbers is provided in Table 2.

Table 2. Treatments and associated cluster and tree counts for desert ash control.

Treatment abbreviation	No. of clusters per treatment	Tree count	Average trees per cluster
M-Lo	10	30	3.0
M-Hi	9	33	3.7
MG	10	30	3.0
G	8	27	3.4
T	9	32	3.6

Trees were GPS-located, individually marked with mining flags and stumps were labelled to find and correctly identify each tree at future assessments.

To assess the effectiveness of the selected herbicides trees were assessed in February 2012 (11 months after treatment (MAT)), February 2013 (23 MAT) and February 2014 (35 MAT). All trees were assessed for regrowth characterised as the presence of shoots arising from the stump (Figure 1).

Shoots arising near to treated stumps (≥1.5 m away) were considered independent trees. Shoots closer than 0.25 m were dug up to verify they were independent seedlings or connected to the treated stump.

RESULTS

Regrowth occurred in all treatments, however, the nature and extent of the regrowth varied according to herbicide and time since treatment (Table 3). The number of stumps with regrowth increased over time for all treatments that contained metsulfuron-methyl. For glyphosate and triclopyr the number of stumps with regrowth reduced over time (Table 3).

Table 3. Summary of observed regrowth at each assessment.

Treatment	Feb–12 (11 MAT)				Feb–13 (23 MAT)				Feb–14 (35 MAT)			
	R	% R	WB	%WB	R	% R	WB	%WB	R	% R	WB	%WB
M-Lo	6	20.0	0	0	10	33.3	0	0	12	40.0	0	0
M-Hi	2	6.1	1	3.0	4	12.1	0	0	7	21.2	0	0
MG	1	3.3	3	10.0	3	10.0	1	3.3	4	13.3	1	3.3
G	0	0.0	5	18.5	0	0.0	3	11.1	0	0.0	1	3.7
T	4	12.5	0	0	2	6.3	0	0	2	6.3	0	0

NR = Stumps with no regrowth (n); R = Stumps with regrowth (n); % R = Percent of stumps with regrowth; WB = stumps with witches' broom (n); %WB = Percent of stumps witches' broom. MAT = Months after treatment.

Figure 1. Characteristic regrowth: Example of shoot arising from the base of a desert ash tree treated by cut stump method.

By 35 MAT, regrowth was observed in 40% of stumps treated with metsulfuron-methyl at label rate and 21% of trees treated with this herbicide at high rate. Typically regrowth comprised robust tall stems with normal shaped leaves (Figure 2, top). Similar regrowth was observed from the stumps treated with triclopyr, however, this only arose from 6% of the stumps with this treatment.

Regrowth from the stumps treated with glyphosate and glyphosate mixed with metsulfuron-methyl was characterised as witches' broom (Figure 2, bottom), that is, a dense mass of shoots arising from a single point. Glyphosate is renowned for inducing witches' broom (e.g. Yonce and Skroch 1989), but it can be caused by any damage to the apical meristem. This reduces the rate of auxin production, which releases the stem from apical dominance and results in uncharacteristically bushy plants. All regrowth associated with glyphosate-only treated stumps was witches' broom, characterised as multiple stunted stems without properly formed leaves. In contrast, regrowth

Figure 2. Regrowth from metsulfuron-methyl treated stumps, 35 MAT (top). Witches' broom (circled) from glyphosate-treated stump (bottom).

associated with glyphosate + metsulfuron-methyl was only sometimes witches' broom, which occasionally transformed to healthy regrowth or died.

DISCUSSION

The most effective herbicide was glyphosate (no healthy regrowth in any of the 27 trees treated), which is also the most environmentally suitable as it is registered for use where contamination of water may occur. We have not explored other proprietary products that contain glyphosate that have a higher concentration of glyphosate (e.g. 510 and 540 g L^{-1}), some of which are now approved for use in aquatic situations.

The next best herbicide was triclopyr, with regrowth from two of the 32 trees treated. In Victoria, ester forms of triclopyr are currently restricted in their use and would require a permit to use, so there is little incentive to use this herbicide.

The combination of metsulfuron-methyl + glyphosate was a formulation anecdotally recognised for providing good woody weed control. The existence of minor use permits (e.g. PER9907, issued by the Australian Pesticides and Veterinary Medicines Authority, APVMA) for this herbicide combination was viewed as credible evidence of efficacy. Its effectiveness in this trial was not sufficient to warrant its use on this species, or any product that contains metsulfuron-methyl.

The outcome of this trial exemplifies the need for long term monitoring (>3 y) to determine the real effectiveness of herbicides. This long term monitoring has allowed us to monitor the witches' broom growth form through time and demonstrate that this form of regrowth does not transform to normal regrowth for this species when treated with glyphosate. As there is no known residual effect of glyphosate, it follows that witches' broom shoots should survive once herbicidal effect ceases. Why they did not persist is not known.

Regrowth was observed from additional stumps at our final monitoring date (35 MAT) in all metsulfuron-methyl treatments that had no record of regrowth prior to this date. Further, some of the regrowth from stumps 23 MAT had died by 35 MAT for the glyphosate and triclopyr treatments. Because of this, we do not know how these results may change with additional monitoring in the future.

An alternative application technique is stem injection, which is favoured at sites where removal of woody debris is impractical or not necessary. We have established two further trials to determine the effect of herbicide application method (cut stump, stem injection) and time of application (winter, summer, autumn) on desert ash control.

ACKNOWLEDGMENTS

This work was funded by Melbourne Water. Control activities at both Emu Creek and Musk Creek were performed by staff of Thiess Melbourne Water Alliance. We thank the owners and managers of the properties adjacent to the experimental sites for their support with this research by allowing access into their properties.

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