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Evaluating the efficacy of the EZ-Ject herbicide system in Queensland, Australia

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Abstract. The EZ-Ject herbicide system was evaluated as a stem injection method for controlling woody weeds in a range of situations where traditional chemical application methods have limited scope. The equipment was trialled on three Queensland weed species; pond apple (*Annona glabra*), velvety tree pear (*Opuntia tomentosa*) and yellow oleander (*Cascabela thevetia*); at five different cartridge densities (0, 1, 2, 3 and 4) and with two herbicides (glyphosate and imazapyr).

Cartridges filled with imazapyr were significantly more effective at controlling the three woody weed species than those filled with glyphosate. Injecting plants with three imazapyr cartridges resulted in plant kills ranging from 93 to 100%, compared with glyphosate kills of 17 to 100%. Pond apple was the most susceptible species, requiring one imazapyr cartridge or two glyphosate cartridges to kill 97 and 92% of the treated plants. Plant mortality increased as the number of cartridges injected increased. Mortality did not differ significantly for treatments receiving three and four imazapyr cartridges, as these cartridge densities met the criterion of injecting one cartridge per 10-cm basal circumference, a criterion recommended by the manufacturers for treating large plants (>6.35 cm in diameter at breast height).

The cost of treating a weed infestation of 1500 plants ha^{-1} with three cartridges per tree is \$1070 ha^{-1}, with labour costs accounting for 16% of the total. The high chemical costs would preclude this technique from broad-scale use, but the method could have application for treating woody weeds in sensitive, high conservation areas.

Additional keywords: glyphosate, imazapyr, stem injection, woody weed control.

Introduction

Forestry has used the technique of injecting herbicides into the sapwood of trees to kill unwanted and non-commercial trees since the 1950s (Leonard 1956; Johansson 1985; Whitford *et al*. 1995). Undiluted 2,4-D amine was commonly used at that time and injection sites were cut with an unmodified axe (Peevy 1972).

The EZ-Ject herbicide system is a relatively new tool trademarked by Monsanto Canada Inc. (Canada trademark #TMA389314; Seravia 2011; USPTO 2011) for controlling woody weeds by stem injection. The unit consists of two parts. The 1.5-m-long stainless steel shaft contains a four-chambered magazine with each chamber able to hold up to 100 .22-calibre brass cartridges filled with 0.15 g of water-soluble herbicide (83.5% a.i.) of either glyphosate or imazapyr. The head contains the gravity-fed, spring-loaded assembly which injects a cartridge directly into the cambium layer of the plant when the lance is thrust firmly against the tree. The sloped head and gripping teeth at the end of the lance help ensure the correct downward angle for placement of the cartridges. A new cartridge drops into the chamber for the next injection once the pressure is released. No mixing of or contact with the herbicide is required by the operator. The lance weighs less than 4.5 kg when fully loaded. Two herbicides, glyphosate and imazapyr, are registered for use with the lance in the USA and Canada (ArborSystems 2002). The registered rate, as per product label recommendations (ArborSystems 2002), is one cartridge per stem for plants ≤6.35 cm in diameter at breast height (DBH) and, for larger plants, one cartridge approximately every 10 cm around the trunk, cartridges to be injected below all major branches. The lance is not designed for plants with basal diameters <1.5 cm (Franz and Keiffer 2000; Hartman and McCarthy 2004). Plants may be injected at any time of the year and in all weather conditions, including rain (Bergerud 1988; van den Meersschaut and Lust 1997).

Control using the EZ-Ject system has varied among plant species. Over 95% of treated *Prunus serotina* Ehrh., family Rosaceae (van den Meersschaut and Lust 1997), and *Ailanthus altissima* (Mill.) Swingle, family Simaroubaceae (Meloche and Murphy 2006), were controlled using one glyphosate cartridge for every 5- and 3-cm DBH, respectively. However, *Populus tremuloides* Michx., family Salicaceae, *Betula papyrifera* Marsh., family Betulaceae (Pitt *et al*. 2004) and

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Schinus terebinthifolius Raddi, family Anacardiaceae (Laroche and Barker 1994), were poorly controlled when injected with one glyphosate cartridge for every 5-cm DBH.

This paper examines the efficacy and cost of using the EZ-Ject herbicide system on woody weeds in Queensland, Australia. Three woody weeds were chosen, each from a different family and each a declared plant of Queensland under the *Land Protection* (*Pest and Stock Route Management*) *Act 2002* (LPA 2002). If effective, the herbicide lance would allow individual plants to be treated without affecting surrounding native vegetation in sensitive areas.

Materials and methods

Targeted species

Yellow oleander [*Cascabela thevetia* (L.) Lippold], family Apocynaceae, is native to tropical South America and the West Indies and has been extensively planted as an ornamental tree in domestic gardens and amenity situations. It can grow up to 10 m high, has a milky sap, narrow, pointed leaves and bell-shaped, waxy, slightly fragrant flowers up to 5 cm in diameter, yellow or peach coloured. Lantern-shaped fruit are 2.5–4 cm in diameter, green turning black when ripe and contain 1–2 seeds. Older plants can produce large quantities of seed. All parts of the plant are poisonous, seeds being the most toxic. Yellow oleander has become a highly invasive weed in parts of Queensland, dominating creek systems, threatening sustainable pasture production and the environment (Anon. 2009*a*). Yellow oleander is now a class 3 declared plant in Queensland (LPA 2002).

Velvety tree pear (*Opuntia tomentosa* Salm-Dyck), family Cactaceae, grows up to 5 m high with a central woody trunk that can be over 30 cm in diameter. Dull green oblong cladophylls grow 15–35 cm long, 8–12 cm wide, 1.5–2.0 cm thick and have a dense covering of short fine hairs. Flowers are a deep orange colour and the dull red coloured, egg-shaped fruit is ~5 cm long and 3 cm wide with many seeds in the reddish pulp. This plant can form dense stands which replace useful species. In Queensland, velvety tree pear is found predominantly in the brigalow belt but its range is still expanding (Anon. 2009*b*). Velvety tree pear is a class 2 declared plant in Queensland (LPA 2002).

Pond apple (*Annona glabra* L.), family Annonaceae, is native to the Americas and West Africa. It was introduced to Australia as grafting stock for custard apple (*Annona* spp.). Pond apple grows in flooded areas in fresh, brackish or salt water, is semi-deciduous and is usually 3–6 m tall, although it can grow up to 15 m. It usually has a single trunk, though seedlings growing in clumps give the appearance of a multi-stemmed plant. Stems have a thin grey bark and are often swollen at the base, with mature plants developing buttressed roots. Pond apple leaves are arranged alternately on the stems, grow 7–12 cm long, are light to dark green on the upper surface and paler underneath and have a prominent midrib. Flowers are visually insignificant, creamy-white to light yellow, 2–3 cm in diameter. The spherical-shaped fruit is 5–15 cm in diameter, green turning yellow then black and contains 100 or more pumpkin-like seeds. Fruits and seeds can float and remain viable in fresh, brackish or salt water for 12 months (Setter *et al*. 2008). Seed is also spread by cassowaries (Westcott *et al*. 2008) and feral pigs (Setter *et al*. 2002), up to 5 and 10 km, respectively. Pond apple's invasiveness and competitive nature threaten wetlands and riparian ecosystems and can result in dense monocultures. It has been named a Weed of National Significance in Australia (Thorp and Lynch 2000) and is a class 2 declared plant in Queensland (LPA 2002).

Study sites

The three selected weed species are from three different regions in Queensland. The yellow oleander infestation was dominating a sandy creek system (19.818°S, 146.558°E) near Mingela, extending into the surrounding grazing land. The soil above the creek bed was derived from volcanic rock. Dense stands of yellow oleander had no ground cover; beyond these areas ground cover was mainly *Urochloa mosambicensis* (Hack.) Dandy, with scattered dense stands of *Parthenium hysterophorus* L. Other vegetation included *Melaleuca bracteata* F.Muell. (black tea-tree), *M. trichostachya* Lindl. (tea-tree), *Eucalyptus crebra* F.Muell. (narrow-leaved ironbark) and *Cryptostegia grandiflora* R.Br. (rubber vine).

The velvety tree pear site was along the roadside extending into grazing land near Inglewood (28.415°S, 151.082°E) on Cainozoic alluvial plains with both sandy soils and cracking clays. Other vegetation included *Eucalyptus* spp., *Angophora* spp., *Callitris* spp. and grasses including *Bothriochloa decipiens* (Hack.) C.E.Hubb. (red grass), *Enteropogon acicularis* (Lindl.) Lazarides (curly windmill grass), *Aristida ramosa* R.Br. (purple wiregrass) and *Tripogon loliiformis* (F.Muell.) C.E.Hubb. (five minute grass).

The pond apple site (17.272°S, 145.952°E) was in the floodplain of the Russell River near Babinda, on moderate to poorly drained alluvial plains of moderate fertility, where the weed had invaded a mesophyll vine forest. *Archontophoenix alexandrae* (L.) Merr. (alexander palm), *Hibiscus tiliaceus* L. (native hibiscus), and *Blepharocarya involucrigera* F.Muell. (rose butternut) were other woody species and *Sphagneticola trilobata* (L.C.Rich.) Pruski (Singapore daisy) was the predominant ground cover above the tidal water line.

Rainfall totals for 2008 and 2009, respectively, were 1017 and 1185 mm for Mingela, 550 and 413 mm for Inglewood and 4585 and 4980 mm for Babinda. Rain days ($\geq$3 mm) per year for the sites for 2008 and 2009, respectively, were 48 and 57 days for Mingela, 41 and 36 for Inglewood and 139 and 120 for Babinda.

Experimental design

At each of the three sites the experiment consisted of a 5×2 factorial replicated 4 times using a split-plot design. Factor A was the five cartridge densities (0, 1, 2, 3 and 4 cartridges) assigned to the mainplots, and factor B was the two herbicides (glyphosate and imazapyr) assigned to the subplots. In this trial, control refers to plants devoid of both cartridge and chemical. At each site a total of 540 plants were randomly selected, tagged and measured for DBH, plant height and basal circumference (BC), with each treatment containing 15 plants. Plants selected contained healthy crowns, single main trunks with basal stem diameters between 10 and 15 cm. Basal stem circumference for these plants averaged 37.0 (s.e.m. 0.22), 42.2 (s.e.m. 0.26) and 40.1 (s.e.m. 0.27) cm, respectively, for yellow oleander, pond apple and velvety tree pear. All treatments were applied between March and April 2008.

The EZ-Ject system was used to inject cartridges at a height ~10 cm above ground level. When more than one cartridge was injected, they were evenly spaced around the plant's trunk circumference.

Trial site measurements

Five plots of 10 × 10 m (total area of 500 m^2) were randomly selected within each trial site. Within each plot all plants >0.5 m tall were recorded. Seedling and juvenile plants <0.5 m of treated species were also recorded in each plot by randomly selecting five 1 × 1-m quadrats (total sample area of 25 m^2).

Evaluating plant injury

Plant injury was assessed at 35, 190 and 535 days after treatment (DAT) using a rating scale of 1 (healthy) to 10 (dead – no live tissue in main stem and taproot of plant). Plant mortality at the final assessment (535 DAT) is presented here.

Cladophyll survival

At the final assessment in the velvety tree pear trial, cladophylls that had dropped from plants after treatment yet remained green and viable were counted.

Treatment costs

To assist in determining the costs of treating plants with the EZ-Ject herbicide system, five additional yellow oleander plots with varying plant densities (PD) (500, 1000, 1500 and 2000 plants ha^{-1}) were treated. Each PD was injected with four cartridge densities (1, 2, 3 and 4 cartridges), replicated 5 times. The total time required to apply the cartridges in each density class was recorded.

Statistical analysis

An ANOVA was performed on plant mortality. Where the F-test was significant ($P < 0.05$) the mean differences were determined using Fisher's Protected Least Significant Difference test. Plant mortality was arcsin-transformed before analysis and back-transformed before presentation. Height, BC, PD, cartridge density and labour costs were subjected to regression analysis. All analyses were performed using Systat 9 Statistical Program (SPSS Inc., Chicago, IL, USA).

Results

Plant density

Weed density at each treatment site for each of the targeted species averaged 15 880 (s.e.m. 3174), 7480 (s.e.m. 2425) and 1580 (669 s.e.m.) plants ha^{-1}, respectively, for pond apple, yellow oleander and velvety tree pear plants >0.5 m (Table 1). Seedling and juvenile density at the respective sites comprised 97, 41 and 80% of the total population (Table 1).

For all species, a positive linear relationship was observed between BC (cm) and DBH (cm). The equations for the three species all differed significantly ($P < 0.0005$). The equations describing the lines are:

$$\text{Pond apple: BC} = 8.383 + 7.14\ \text{DBH}, \quad (R^2 = 0.55),$$

$$\text{Yellow oleander: BC} = 2.611 + 4.873\ \text{DBH}, \quad (R^2 = 0.88),$$

and

$$\text{Velvety tree pear: BC} = 0.796 + 17.499\ \text{DBH} - 1.34\ \text{DBH}^2, \quad (R^2 = 0.99).$$

Trial results

Irrespective of species or chemical trialled, efficacy increased significantly ($P < 0.0005$) as the number of cartridges increased (Fig. 1). Plant mortality ranged from 7 to 100% depending on species, herbicide and number of cartridges injected. The EZ-Ject herbicide system was most effective on pond apple, killing 90%, and least effective on yellow oleander, killing 67% of the treated plants (values are means of all cartridges injected and herbicides combined) (Fig. 1). Imazapyr was the most effective chemical at killing plants, significant at the $P < 0.0005$ level for yellow oleander and velvety tree pear and $P = 0.0003$ for pond apple, when compared with glyphosate, irrespective of the number of cartridges injected into the treated plant (Fig. 2).

The percentages of treated plants corresponding to the EZ-Ject label recommendations of one cartridge for trees with DBH <6.35 cm, one cartridge every 10-cm BC for larger trees and a rate of one cartridge every 3-cm DBH as used by Meloche and Murphy (2006) were also calculated. All treated yellow oleander, pond apple and velvety tree pear plants in this trial received one cartridge based on DBH <6.35 cm. Based on the one cartridge for every 10 cm-BC criterion for larger trees, 90% (yellow oleander), 67% (pond apple) and 76% (velvety tree pear) of the treated plants had received three to four cartridges while all of the yellow

Table 1. The population structure of pond apple, yellow oleander and velvety tree pear at three Queensland sites
BC, basal circumference; DBH, diameter at breast height

Species	Size class	Population density (no. ha^{-1}) (mean ± s.e.m.)	BC (cm) (mean ± s.e.m.)	Height (m) (mean ± s.e.m.)	DBH (cm) (mean ± s.e.m.)
Pond apple	>0.5 m	15 880 ± 3174	43.3 ± 1.16	6.13 ± 0.03	4.89 ± 0.12
	<0.5 m	511 600 ± 403 217	–	–	–
Yellow oleander	>0.5 m	7500 ± 2425	11.8 ± 0.62	2.75 ± 0.06	1.82 ± 0.10
	<0.5 m	5200 ± 1625	–	–	–
Velvety tree pear	>0.5 m	1580 ± 669	61.6 ± 6.34	2.10 ± 0.14	12.3 ± 1.20
	<0.5 m	6400 ± 2993	–	–	–

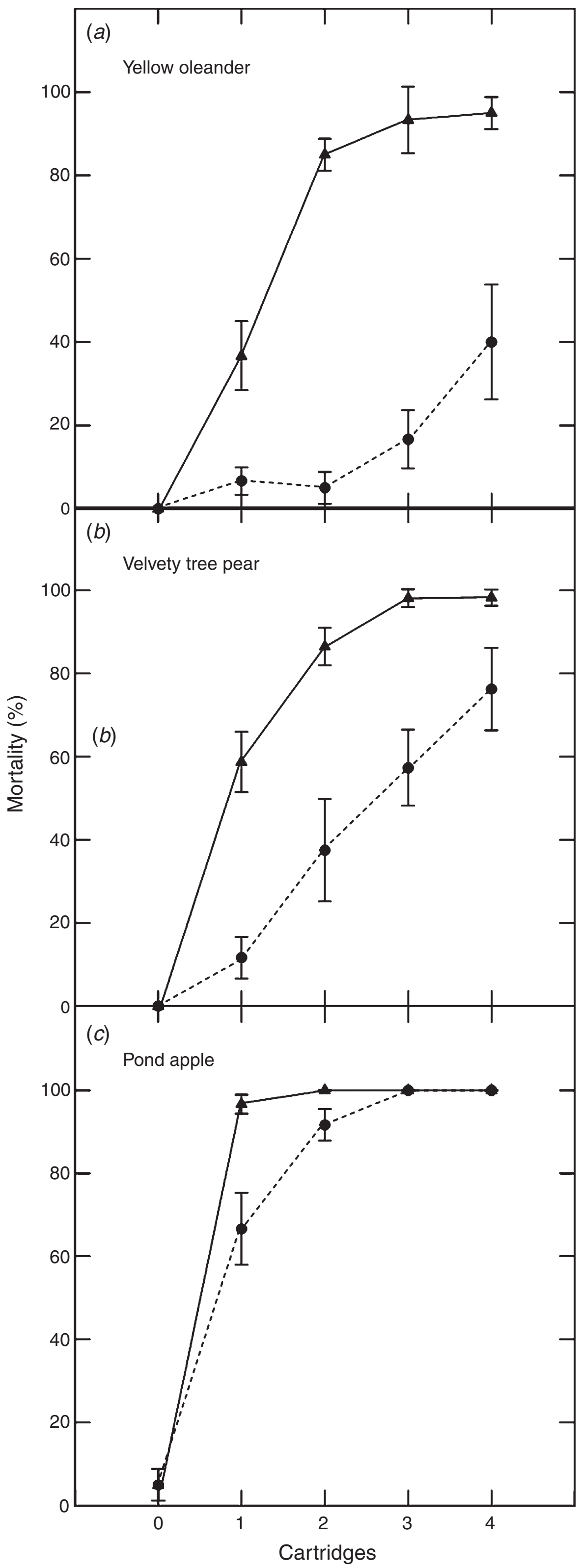

Fig. 1. Average plant mortality recorded for (*a*) yellow oleander, (*b*) velvety tree pear and (*c*) pond apple when injected with increasing number of cartridges containing glyphosate (●) and imazapyr (▲). Vertical bars represent the standard error of the mean.

oleander and 99% of the pond apple received only one or two cartridges at the 3-cm DBH rate (Table 2).

Rearranging the dataset based on the various criteria used for cartridge injection according to plant size demonstrated that efficacy would have varied significantly depending on the criterion used for cartridge injection, glyphosate efficacy being affected the most (Table 3). For example, injecting yellow

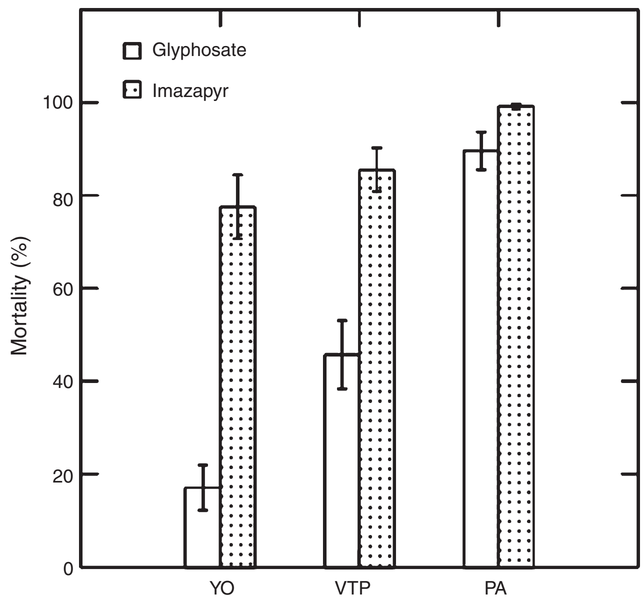

Fig. 2. Average plant mortality recorded for glyphosate (open bars) and imazapyr (shaded bars) treatments for yellow oleander (YO), velvety tree pear (VTP) and pond apple (PA), irrespective of number of cartridges injected.

Table 2. Percentage of plants treated in this study matching each of three cartridges/circumference or cartridges/diameter criteria from product label or reported in the literature (ArborSystems 2002; Meloche and Murphy 2006)

Criteria are one cartridge every (a) 10-cm basal circumference (BC), (b) 3-cm diameter breast height (DBH) and (c) 6.35-cm DBH

Species	Cartridges	10-cm BC (%)	3-cm DBH (%)	6.35-cm DBH (%)
Yellow oleander	1	–	76	100
	2	–	24	–
	3	41	–	–
	4	49	–	–
	5	10	–	–
Pond apple	1	–	41	100
	2	–	58	–
	3	11	1	–
	4	56	–	–
	5	29	–	–
	6	4	–	–
Velvety tree pear	1	–	–	–
	2	–	–	100
	3	23	–	–
	4	53	100	–
	5	23	–	–
	6	1	–	–

oleander plants <6.35-cm DBH with one cartridge would have resulted in kills of 7 and 37% for glyphosate and imazapyr, respectively. The criterion of one cartridge for every 10-cm BC would have increased the number of cartridges used to three or four per plant while improving kills to 32% (glyphosate) and 100% (imazapyr). Injecting cartridges based on BC obtained kills comparable to our trial of injecting plants with three and four cartridges.

Cladophyll survival

Thirty percent of the velvety tree pear plants had dropped cladophylls that were still viable 535 DAT. Fifty percent of the plants treated with one or two glyphosate cartridges or with two imazapyr cartridges had viable cladophylls; no plants treated with three or four imazapyr cartridges had viable cladophylls. The largest number of viable cladophylls found beneath plants was three in the one cartridge glyphosate treatment.

Treatment cost and plant density

The time (T) (in hours) required to treat 1 ha of yellow oleander at varying PD injected with one to four cartridges per tree using the EZ-Ject method was calculated using the following equations, derived from regression analysis based on plot density data (Fig. 3):

$$\text{One cartridge per tree, } T = 0.255 + 0.0019\ \text{PD}, \quad (R^2 = 0.89),$$

$$\text{Two cartridges per tree, } T = 0.423 + 0.0031\ \text{PD}, \quad (R^2 = 0.96),$$

$$\text{Three cartridges per tree, } T = 0.5277 + 0.0042\ \text{PD}, \quad (R^2 = 0.96),$$

and

$$\text{Four cartridges per tree, } T = 0.4109 + 0.0056\ \text{PD}, \quad (R^2 = 0.93).$$

As a working example, an infestation of 1500 plants ha^{-1} injected with one, two, three or four cartridges would take 3.14, 5.12, 6.8 and 8.76 h, respectively. Assuming labour costs of $25 h^{-1} and a cartridge cost of $0.20, it would cost $378, $728, $1070 and $1419 ha^{-1} to treat 1500 plants using one, two, three and four cartridges, respectively. The cost to treat an individual plant would range from 25 to 95 cents per plant, depending on cartridge density.

Table 3. Percentage mortality and number of cartridges injected for each of the treated species tested in this study and for plants matching one of three cartridges/circumference or cartridges/diameter criteria reported in the literature (ArborSystems 2002; Meloche and Murphy 2006)

Criteria are one cartridge every (a) 10-cm basal circumference (BC), (b) 3-cm diameter breast height (DBH) and (c) 6.35-cm DBH

Species	Treatment	Cartridges	Trial (%)	10-cm BC (%)	3-cm DBH (%)	6.35-cm DBH (%)
Yellow oleander	Glyphosate	0	0.0	–	–	–
		1	6.7	–	4.2	6.7
		2	5.0	–	0	–
		3	16.7	27.3	–	–
		4	40.0	32.4	–	–
	Imazapyr	0	0.0	–	–	–
		1	36.7	–	43.5	36.7
		2	85.0	–	58.3	–
		3	93.3	100	–	–
		4	94.9	100	–	–
Pond apple	Glyphosate	0	5.0	–	–	–
		1	66.7	–	72	66.7
		2	91.7	–	85.7	–
		3	100.0	100	–	–
		4	100.0	100	–	–
	Imazapyr	0	0.0	–	–	–
		1	96.7	–	96	96.7
		2	100.0	–	100	–
		3	100.0	100	–	–
		4	100.0	100	–	–
Velvety tree pear	Glyphosate	0	0.0	–	–	–
		1	11.7	–	–	–
		2	37.5	–	–	37.7
		3	57.4	93.8	–	–
		4	76.3	79.3	76.7	–
	Imazapyr	0	0.0	–	–	–
		1	58.8	–	–	–
		2	86.5	–	–	86.4
		3	98.2	100	–	–
		4	98.3	100	98.3	–

Discussion

This study established that the EZ-Ject herbicide system is an effective tool for controlling individual woody plants, although the degree of control varied among species, with efficacy influenced by herbicide and number of cartridges injected. Efficacy was highest for pond apple, followed by velvety tree pear and yellow oleander. One imazapyr-filled cartridge controlled

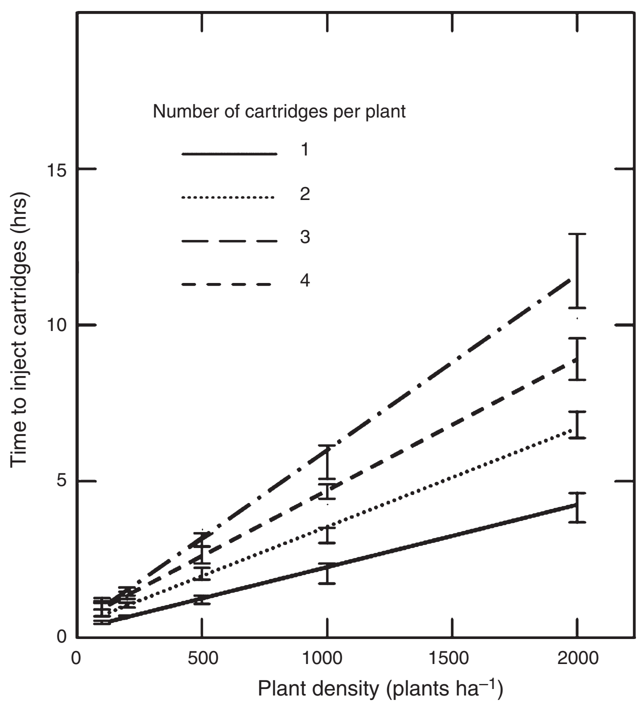

Fig. 3. Relationship between times required to inject one, two, three or four cartridges into varying yellow oleander densities.

97% of the treated pond apple, 59% of the treated velvety tree pear and 37% of the treated yellow oleander. Increasing the number of injected cartridges to three improved kills to 100, 98 and 93%, respectively. Glyphosate at three cartridges controlled 100% of the treated pond apple, 57% of velvety tree pear and 17% of yellow oleander-treated plants.

Our study showed that the best criterion for the number of cartridges required when treating woody plants is one cartridge for every 10-cm BC. This criterion averaged kills of 86% irrespective of herbicide and species, compared with 63 and 55% for injecting cartridges based on criteria of one cartridge for every 3- and 6.35-cm DBH, respectively.

Damage to non-target species should also be considered when selecting herbicides. Previous research has shown that imazapyr can affect untreated trees neighbouring treated trees (DiTomaso and Kyser 2007; Dubois *et al*. 2001; Kochenderfer *et al*. 2001; Lewis and McCarthy 2008). Lewis and McCarthy (2008) found injecting tree-of-heaven [*A. altissima* (Mill) Swing] with four imazapyr cartridges using the EZ-Ject system resulted in 100% kills of tree-of-heaven but also killed 17.5% of non-injected vegetation within 3 m of the targeted plants. In our trial, a yellow oleander tree abutting a tree treated with three imazapyr cartridges and one abutting a tree with four imazapyr cartridges also died. Four other plants within 2 m of imazapyr-injected plants showed some herbicide damage. No other plants were affected.

Cladophylls are reported to aid *Opuntia* dispersal (Monteiro *et al*. 2005) as they remain alive for up to 12 months after being removed from the plant (Nobel and Castaneda 1998). In our trial, 30% of the treated plants exhibited up to three separate viable cladophylls under the mother plant 535 DAT. Glyphosate treatments, in particular plants injected with one cartridge, could exacerbate velvety tree pear spread, necessitating follow-up control in order to manage cladophyll regeneration.

The management of weed infestations, and whether to attempt eradication or containment, often depends on the expected costs of control relative to the available budget (Cacho *et al*. 2008). The density of infestations often guides the choice of control method, with herbicides generally selected when weed density is low to medium (Vitelli 2000). Our trial evaluated a new technique for controlling woody weeds with herbicides in sensitive landscapes. To ensure kills of over 90%, one cartridge needed to be injected for every 10-cm tree BC. To achieve this, three cartridges were required at a labour cost of 24, 17, 13, 12 and 11 cents per tree to control plants within densities of 100, 200, 500, 1000 and 2000 plants ha^{-1}. Hartman and McCarthy (2004) reported the EZ-Ject system to be 43% faster than the cut stump method. Substituting labour costs of \$25 h^{-1}, foliar, basal bark and cut stump labour would respectively cost 59, 70 and 58 cents to treat PD of 100 plants ha^{-1}, and 27, 32 and 27 cents to treat PD of 1000 plants ha^{-1} (Vitelli *et al*. 2008). The EZ-Ject herbicide system would result in labour savings of 60–37% depending on PD when compared with cut stump or foliar treatments. The cost of cartridges, however, would restrict its application to areas of high conservation value. Conventional stem injection methods would be more cost effective, with labour costs of 43 cents and herbicide costs of 8 cents per tree (Kochenderfer *et al*. 2004). The EZ-Ject system is reported to be best suited for controlling a relatively small number (<100) of woody stems per ha (Pitt *et al*. 2004). Our trials indicated that the technique would cost \$84 ha^{-1} (labour plus herbicide) to treat 100 plants ha^{-1}, with costs increasing to \$1420 ha^{-1} for treating 2000 plants ha^{-1}.

The trial indicated that the EZ-Ject herbicide system is an effective method of controlling the three plant species tested. Registering the technique and herbicide formulation in Australia would provide an alternative technique for woody weed control, particularly in sensitive areas. Use of the herbicide lance would allow individual plants to be treated without affecting surrounding native vegetation, though susceptible species within 3 m of plants injected with three to four imazapyr cartridges could be affected. Plants in wet areas could be treated without fear of water contamination. This treatment method could be used year round in Australia. Operators would have no contact with herbicide mixtures and would be able to stand at a distance from plants, helping to avoid contact with any thorns or spines.

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