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# Counting the Cost of Revegetation: is Direct Seeding Cheaper than Planting Tube-stock?

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## Abstract

Direct seeding is often assumed to be cheaper than planting tube-stock, but limited data exist to compare the relative costs of the two techniques. At four riparian sites in Victoria, we assessed the number of plants established over time in the months after direct seeding or planting. The costs of surviving plants and of weed management were calculated. Plants were 11 times cheaper when established by seeding (\$1.88/plant) than when planted (\$21.03/plant). Incorporating weed management costs, direct seeding was 1.3–2.4 times more cost-effective than planting tube-stock, although costs were high for both techniques.

## Introduction

Active revegetation involves either planting nursery-grown stock or direct seeding. Planting is generally considered to be a more reliable revegetation technique because the early phases of plant establishment, when a seedling is most vulnerable, have been completed prior to planting. In contrast, establishment from seed sown directly into a site may be constrained by adverse environmental conditions, resulting in low establishment rates.

In terms of direct costs however, it is more expensive to plant than to sow (Palma and Laurence 2015; Schirmer and Field 2000), due to the relative costs of plants and planting compared with seed and sowing. Although these costs are well understood, there are few published studies analysing the cost-effectiveness of the two revegetation techniques, in terms of plant establishment over time. Assessing plant numbers at 18 months since establishment, Grose (2013) found that planting slender banksia (*Banksia attenuata*) in Western Australia cost approximately 10 times more than sowing seed, while Cole *et al.* (2011) costed planting at 10–30 times more expensive than seeding for rainforest species in Costa Rica, based on plant survival after two years. A trial in riparian sites in California found that planting was twice as expensive as niche direct seeding (Palmerlee and Young 2010).

Historically, riparian revegetation in the Melbourne region has involved planting tube-stock into sites which are spot-sprayed prior to planting, with regular post-planting weed maintenance undertaken to manage the high weed abundance frequently found in riparian areas. Herbivore protection measures are also often required. Although relatively successful, such planting operations are expensive which limits the potential extent of revegetation, so there is interest in determining if direct seeding is more cost-effective. The limited use of direct seeding to date is due to a perception of unreliable outcomes, compounded by the difficulty of undertaking post-sowing weed control. The aim of this study was to compare the cost-effectiveness of planting and direct seeding tree and shrub species at riparian sites, taking into account weed management costs before and after plant establishment.

## Methods

Plant numbers were assessed in sown and planted areas at four riparian sites where both revegetation techniques had been used. The cost/surviving plant was then calculated. To estimate this figure for plants in sown areas we assumed seed cost \$1 500/kg and was sown at 1kg/ha. Including the cost of sowing, estimated at \$1 800/ha, brought the total cost of seeding to \$3 300/ha. For tube-stock plants, the cost to supply, plant and guard plants was \$15.70/plant at the Yarra River and Sheepstation Creek sites and \$19.70/plant at the Deep Creek and Emu Creek sites (based on existing Melbourne Water data). The cost/surviving plant was calculated by allocating the total cost of installing all the tube-stock plants initially planted, across those plants surviving at the time of assessment.

Weed management costs before and after revegetation were then added to the plant costs to estimate overall project costs. All activities were costed using commercial labour rates and included project management costs. A four-person field crew was costed at \$1 700 per day. Pre-planting weed control required two spray applications (\$3 400/ha), while it cost \$13 600/ha to prepare sites for direct seeding (four spray applications requiring two crew days each). Weed control after planting was costed at \$4.80/plant over two years, while herbicide-only maintenance of direct seeded sites was costed at \$10 200/ha (six spray applications over two years). Hand weeding direct seeded sites monthly for the first three months required 18 crew days, with three additional spray applications required in the following months, costing a total of \$35 700/ha. Estimates of the time required to hand weed were based on three projects only and it is anticipated that the time required will vary between sites.

## Results

Survival of tube-stock decreased over time from 100% at the youngest site to 67% at the oldest site (Table 1). The cost of each surviving tube-stock plant ranged between \$15.70 and \$23.66, averaging \$21.03/plant across all sites. In contrast, the average cost of each direct seeded plant was 11 times cheaper at \$1.88/plant (Table 1). These costs incorporated planting and sowing costs only.

Adding weed management costs to the costs of establishing 2 500 stems per hectare (sph) showed that planting tube-stock was 2.4 times more expensive than direct seeding using only herbicide post-sowing (Table 2). It was still 1.3 times more expensive to plant tube-stock than to hand weed direct seeded sites, even though hand weeding monthly for the first three months after sowing considerably increased the costs of direct seeding.

**Table 1. Cost per surviving plant of seedlings either planted or sown in riparian revegetation sites.**

Site	Planted tube-stock			Direct seeded		
	Site age (months)	Survival	Cost per surviving plant	Site age (months)	Density (plants/ha)	Cost per surviving plant
Yarra River <sup>E</sup>	30	67%	\$23.43	30	1980	\$1.67
Deep Creek <sup>N</sup>	7	82%	\$23.66	19	2730	\$1.21
Emu Creek <sup>N</sup>	6	91%	\$21.32	6	3880	\$0.85
Sheepstation Creek <sup>E</sup>	5	100%	\$15.70	19	870	\$3.79
<b>Average</b>		<b>85%</b>	<b>\$21.03</b>		<b>2,365</b>	<b>\$1.88</b>

Site names followed by E were east of Melbourne (plants cost \$15.70 each); site names followed by N were north of Melbourne (plants cost \$19.40 each).

**Table 2. Projected cost per hectare to plant tube-stock or direct seed riparian revegetation sites\*.**

Activity	Tube-stock	Seeding (spray only)	Seeding (hand weeded)
Site preparation	\$3 400	\$13 600	\$13 600
Plant installation	\$52 600	\$4 700	\$4 700
Maintenance	\$12 000	\$10 200	\$35 700
<b>Total</b>	<b>\$68 000</b>	<b>\$28 500</b>	<b>\$54 000</b>

\*Assuming a target plant density of 2 500 sph, with a tube-stock plant costing \$21.03 and a plant arising from direct seeding costing \$1.88.

## Discussion

The results of this study confirm that direct seeding is cheaper than planting tube-stock in riparian areas on a cost per plant and on a cost-effectiveness basis, incorporating weed management costs. However one limitation of this study, as for other recent studies of revegetation cost-effectiveness (Cole *et al.* 2011; Grose 2013; Palmerlee and Young 2010), is that plant survival was only monitored for a short period. Further evaluations of long term plant survival are required to determine cost-effectiveness of each technique in achieving revegetation outcomes.

The costs of revegetating riparian areas by either method are high. It should be noted that the data presented here do not include the costs of fencing, pest animal control or woody weed control, which may be significant at some sites, but which will be the same for both revegetation techniques. The most comprehensive analysis of revegetation costs in Australia was undertaken in the late 1990s and found that planting tube-stock cost about \$11 000/ha (at 1999 values) (Schirmer and Field 2000). This included project management, monitoring and fencing costs, but no post-planting weed maintenance, and used a labour rate of \$15/hour. A more recent analysis of rainforest replanting projects in northern Australia put the cost at \$61 000/ha, which included \$48 000 for post-planting weed maintenance (Hunt 2008). The requirement to intensively manage weeds in rainforest systems mirrors the situation in riparian areas in the study area. Hand weeding post-sowing is an expensive but potentially effective weed management option; further studies testing varying levels of hand weeding intensity may indicate that lower levels of hand weeding are equally as effective as those tested to date, which would reduce this cost.

From these results, we can conclude that at riparian sites where it is an appropriate revegetation option, direct seeding is likely to be more cost-effective than planting tube-stock, even if hand weeding is required.

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