



When is natural regeneration cheaper? Assessing the costs of getting trees on farms.

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Abstract

Increases in the cover of native vegetation are required to maintain biodiversity, improve water quality and soil health. Shelter provided by native vegetation can also increase the profitability of livestock production enterprises. Tree planting and direct seeding can be labour intensive and expensive. Recent research has shown that there is much potential to increase native vegetation cover through natural regeneration. There is however much uncertainty about when natural regeneration will happen. This uncertainty can translate into risks for land holders, potentially reducing the use of natural regeneration. In this paper we explore the costs of natural regeneration and direct seeding or tubestock planting on a representative farm in central Victoria, considering capital costs and foregone income. Our results suggest that although the capital costs of natural regeneration are far lower than tree planting or direct seeding, the inherent riskiness of natural regeneration can result in greater negative impacts on profitability, especially in high productivity situations. Improving our ability to predict where and when regeneration will occur will be essential if natural regeneration is to be adopted more broadly. We provide some strategies to reduce the risks associated with natural regeneration and outline recommendations for how incentive programs could improve adoption.

Introduction

Targeted broad-scale revegetation is required to manage biodiversity and delivery of ecosystem services throughout the mid and upper catchments of the Murray Darling Basin where wheat-sheep and high rainfall livestock grazing are the primary land uses (Lefroy *et al.* 2005; Vesk and Mac Nally 2006). Although emphasis is often placed on revegetation works via tubestock or direct seeding, these methods can be expensive and labour intensive (Schirmer and Field 2001). While tree planting has been widely promoted for several decades, impacts on landscape-scale vegetation cover have not been significant (Freudenberger *et al.* 2004). An alternative, managing to encourage natural regeneration is often promoted as a cheaper and less labour intensive form of revegetation (Cluff and Semple 1994). It has been suggested that there is much potential to increase tree cover through natural regeneration (Cluff and Semple 1994; Spooner *et al.* 2002; Dorrough and Moxham 2005). Where the likelihood of natural regeneration is high, it seems reasonable to argue that investment in direct seeding or tubestock should only be made to supplement those species likely to re-establish naturally.

Current comparisons of the costs of differing methods of revegetation are based on capital costs, that is the up-front costs of labour, seed, plants, fencing and ground preparation (Schirmer and Field 2001). Natural regeneration, which requires little labour or other costs, can be considered to be a much cheaper alternative over a given establishment area. Why then isn't natural regeneration receiving far more public and private investment?

Natural regeneration is spatially uncertain, that is trees may not establish where land managers want them and their densities may be more or less than desired. This alone could discourage investment. Perhaps more important is temporal uncertainty, due to variation in climate and seed availability, which can be considerable and may overwhelm improvements in regeneration success due to management (eg. control of grazing or competition)(Vesk and Dorrough 2006). These uncertainties add considerable risk to investment in natural regeneration.

Current estimates of regeneration costs do not consider the spatial or temporal uncertainty of establishment. This matters because for each year that establishment is not successful there are losses in income or the natural resource base. These losses can be considered in terms of foregone income (the income that could be made from the revegetating land if managed for an alternative use such as wool production) but could equally be considered in terms of impacts on amount of water to deep drainage or habitat provision over time.

Here we consider the costs of establishing trees on farms with a focus on foregone income. We assess how incorporation of temporal uncertainty in establishment success affects the relative costs of revegetation strategies on a representative wool production farm in the central Victorian uplands. We discuss the implications of this research for management of revegetation and native vegetation management policies and incentives.

Methods

Background

The analyses we present here are for a “representative” wool production farm of 1400 hectares (ha) and carrying 12090 dry sheep equivalents (dse) in the central Victorian uplands. The size, stocking rates, management system and financial situation of the representative farm are based on data collected from 17 farms throughout central Victoria (Moll *et al.* 2005; Crosthwaite *et al.* 2006).

Information on annual revegetation successes, which are key inputs into the scenarios we discuss below, were obtained from a rules-based model of natural regeneration described in Vesk and Dorrough (2006). Although this model was designed for natural regeneration, it can be modified to provide probabilities of establishment success (and 95% confidence intervals) for situations equivalent to direct seeding and tubestock.

Context and initial assumptions

In each scenario discussed below it was assumed that a single 50 ha paddock within the farm would be revegetated, thus no additional fencing costs were considered. It was assumed that the paddock supported scattered mature trees, optimal for the spatial success of natural regeneration. The paddock was either a native dominated low productivity pasture with an average stocking rate of 4 dse/ha (low productivity), or a sown high productivity pasture averaging 12 dse/ha (high productivity).

In the first year livestock were removed from the paddock and sold at \$40/dse. Replacement livestock were brought in at the same cost only once saplings were > 1m in height (escape height, the height at which plants were likely to escape sheep damage). If the paddock was revegetated using direct seeding or tubestock, then preparation and planting were also done in the first year.

Revegetation targets were a woodland structure of approximately 50-100 stems/ha, substantially lower than that planted in most revegetation situations. Costs of revegetation using direct seeding and tubestock were based on figures reported in Schirmer and Field but were adjusted accordingly to account for the reduced target stem densities (direct seeding = \$314/ha; tube stock = \$352/ha). Stem densities from natural regeneration can be high, in this case we assumed that this could subsequently be managed through mechanical or chemical means but costs were not included. In this exercise we do not consider incentive payments, which typically cover some of the establishment works and favour direct seeding and tubestock.

We measured foregone income from managing for increased native tree cover, which is dependent on the time trees take to reach escape height. The time to reach escape height is dependent on establishment success and subsequent growth rates which is a function of rainfall, competition and soil fertility. We assume that landholders have the choice of either maintaining current stocking rates (with a \$20/dse gross margin) and effectively eliminating any potential for broad-scale tree establishment, or undertaking revegetation work. Equally landholders could invest in crops or pasture improvement, in which case the foregone income would differ.

Although we recognise that tree establishment can have local and wider economic benefits, through provision of shelter, increases in the capital value of the asset, lowering of local water tables etc these are not considered in these analyses and assumed to be equal for all scenarios.

Scenarios and incorporating establishment probability into economic models

Three establishment scenarios, natural regeneration, direct seeding and tubestock planting, were considered, each in either a low productivity or high productivity paddock. For each scenario annual probabilities of saplings reaching escape height, and their 95% confidence intervals, were estimated over 15 years using the natural regeneration model. These estimates were used as a basis for defining probability distributions which underlie determinations of when livestock should be returned to the paddock. For each scenario discounted net cash flow budgets over 15 years, and net present value were calculated from 500 simulations. A discount rate of 10% was applied. Mean, upper and lower 95% confidence intervals for net present value are reported here.

Results

Sapling escape

Annual probabilities of sapling escape vary among establishment methods and paddock productivities. Probabilities of sapling escape are low and highly variable for natural regeneration, particularly in high fertility paddocks where competition with pasture is important. Importantly however, the likelihood of escape increases over time and in low fertility paddocks the likelihood of escape is high after 15 years. In contrast the probability of tubestock and direct seeded trees reaching escape height rapidly increases and then plateaus after three (tubestock) or four to five (direct seeding) years and variability in success is substantially lower.

Net Present Value

The net present value varies among the three management options, but most strongly in response to paddock productivity (Figure 1). At low stocking rates, annual foregone income is low and although the likelihood of natural regeneration is low and variability in success is high, it is economically attractive compared to tubestock or direct seeding. The uncertainty about when natural regeneration occurs does however affect the certainty of the economic impact; in the best case scenario, natural regeneration is substantially cheaper than direct seeding or tubestock but in some cases the costs of all revegetation methods will be similar. In a high productivity paddock, up-front costs of establishment have little bearing on net present value, rather the probability of sapling escape and the variability around these estimates is paramount. Our results suggest that in paddocks with high stocking rates tubestock will typically be the least cost method. In contrast natural regeneration is highly risky and economic impacts can be substantially greater.

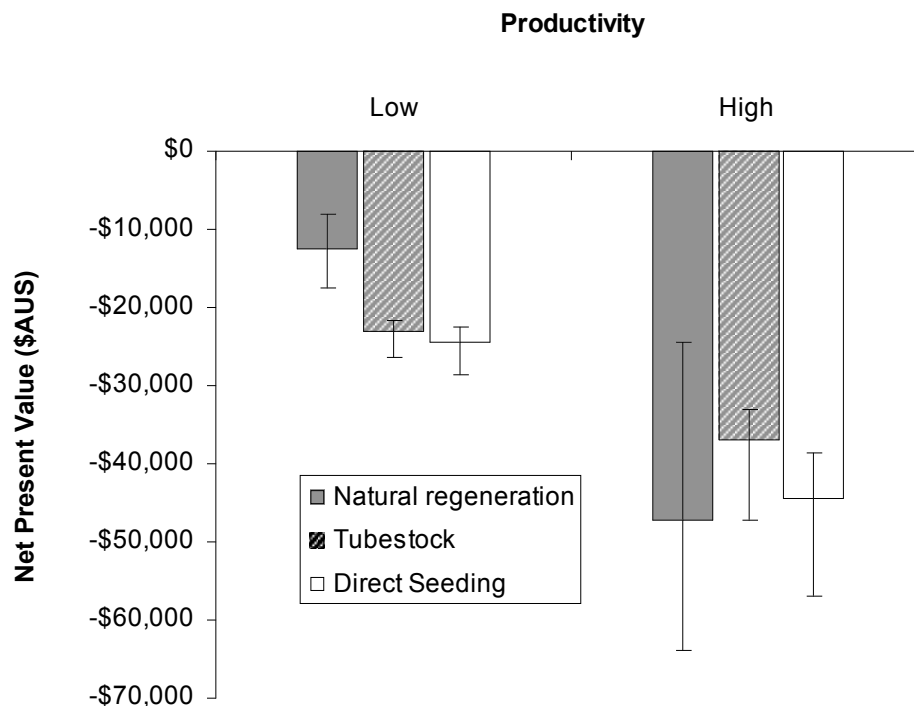


Figure 1. . Net present value (\$Aust.) after fifteen years of investment in revegetation activities in either a low (4 dse/ha) or high (12 dse/ha) productivity 50ha paddock. Upper and lower 95% confidence intervals are shown.

Discussion

Although there is considerable potential to increase native tree cover through natural regeneration, improving our ability to predict where and when regeneration will occur will be essential if natural regeneration is to be adopted more broadly. The modelled data we present here highlights that the uncertainty about when regeneration occurs can translate into economic costs. However, where opportunity costs are low, natural regeneration is the least cost method of revegetation.

Implications for incentives schemes

Although natural regeneration is cheaper than tubestock or direct seeding in low productivity situations, the uncertainties about when it will happen may limit private investment. Incentive schemes targeting natural regeneration need to have long contract times to ensure that sapling escape occurs and benefits of investing in tree cover are obtained. Over long time periods, particularly in lower stocking rate paddocks, natural regeneration is a cost effective means of revegetation.

Because of the uncertainty about when regeneration will occur, short-term, annually funded incentive schemes are unlikely to be successful. Incentive schemes may require flexibility to target years when the likelihoods of regeneration are higher.

The results presented here suggest that the delivery of incentives for revegetation activities need to consider spatial patterns of regeneration likelihood and production capacity. The revegetation of woodlands in high productivity landscapes via

regeneration is risky. In these cases we predict that most revegetation will be via direct seeding or tubestock. The results also highlight why broad-scale revegetation, particularly in high productivity landscapes, is likely to have limited uptake. The opportunity costs, particularly in productive paddocks, are substantial and far outweigh that of establishment costs. Revegetation of woodland in productive landscapes may require payment of some of these costs and auction based systems (Stoneham *et al.* 2003) may be an appropriate mechanism.

Making natural regeneration more cost effective

At present much private investment in natural regeneration is opportunistic, that is it is in response to recruitment events. While this is the cheapest option, it also limits the number of opportunities available to establish trees (seedlings may not be observed before they are grazed and grazing and competition prevent seedling establishment). In the scenarios we presented here we assumed that livestock were removed in the first year and only returned once saplings were > 1m tall. However, unlike tubestock and direct seeding, if no germination occurs in any one year, it would be logical for landholders to return livestock over the summer months, thus reducing foregone income.

Such a strategy should increase subsequent probabilities of seedling recruitment as competition is reduced. This strategy is not unrealistic and similar strategies have been applied with considerable success particularly when timed to coincide with the breaking of drought (Ive 2005). Long-range climate forecasting could further reduce temporal uncertainty and costs of natural regeneration (Howden *et al.* 2004).

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