Economic analysis of poplar planting on steep hill country

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Abstract

This paper analyses the costs and benefits of planting poplars for erosion control, to determine the economic incentives facing farmers. Using cost-benefit analysis over a range of scenarios (e.g., a base scenario, a "most favourable" scenario, and a targeted planting scenario) and underpinning assumptions (e.g., erosion rates, planting densities, stock gross margins), it is found that the private (i.e., on-site) monetary incentives for planting poplars are marginal at best. Even at high expected erosion rates and repair costs, and with harvest values incorporated, the internal rate of return is low (between 5 and 6%). The paper indicates circumstances under which the decision to plant poplars is worthwhile for the farmer. These include circumstances where poplars significantly reduce lamb losses, subsidies are available, or non-monetary factor are important.

Keywords: cost-benefit analysis, erosion, poplars, profit, shelter, sustainability.

Introduction

Farming of the geologically young soils on much steep North Island hill country (LUC Classes 6 and 7) has been perceived as environmentally unsustainable, owing to the potentially high rates of erosion (Mackay *et al.* 1993). Although farming such land is often a marginally economic activity, it continues to be used suggesting that it makes a positive net contribution to the whole farm system (Thorrold 1999).

One tool for potentially improving the environmental sustainability of hill country, is spaced-planting of poplars (MacGregor *et al.* 1999). However, the planting of poplars must also be sustainable from an economic viewpoint. Regional and District Councils need information on the economics of poplar planting as they develop environmental policy. For example, Environment Waikato recently sought the assistance of a group of resource economists to value its "Project Watershed" soil conservation programme, which includes widespread spaced-planting of poplars.

This paper reports on an analysis of the costs and benefits of planting poplars for erosion control, to determine the economic incentives facing farmers.

Method

Cost-benefit analysis was used to evaluate several tree-planting scenarios for erosion prone land, over a range of planting densities.

The key scenarios were as follows, Table 1 has more detail.

Base scenario: Low erosion (10 kg dry matter lost per year on average), realistic gross margin ($44/stock unit), blanket planting at 50 and 100 stems per hectare (sph), no fodder value from the poplars.

Most "favourable" scenario: High erosion (40 kg dry matter lost per year on average), low gross margin ($30/stock unit), blanket planting at 50 and 100 sph, some fodder value from the poplars.

Targeted planting scenario: High erosion (40 kg dry matter lost per year on average), realistic gross margin ($44/stock unit), planting of 25 stems on the quarter of the "model" hectare most likely to slip, the balance left unplanted and unaffected by shade and erosion, some fodder value from the poplars.

The analysis was restricted solely to on-farm effects in order to evaluate the investment decision facing farmers, and utilised a "typical" hectare of steep North Island hill country as the basis for evaluation. The poplar planting investment was compared with maintaining the *status quo*. The calculations included a range of stock gross margins, discount rates, erosion rates, and repair costs.

The decision to invest in poplars for erosion control generates a stream of costs and returns, as does the decision to retain the *status quo*. To compare different cash streams, a single figure must be derived from each. A simple total of each cash stream is not adequate, as this would not account for the "time value of money", i.e., $20 today is worth more than $20 in a year's time because it can be invested and a year's interest received. In cost-benefit analysis, a single figure representing each cash stream is derived by "discounting" the cash

Table 1 Assumptions underpinning the analysis of costs and benefits of planting poplars for erosion control.

All Scenarios	
Dry matter (DM) production (year 0)	6400 kg DM/ha/year
DM consumption	560 kg DM/ha/year/stock unit
Utilisation	70%
Initial stocking rate	8 SU/ha
Value of stock bought or sold	$30/SU
Sheep:cattle ratio	60:40
Gross margin (current)	$44/SU (MAF Policy 2001)
Gross margin (low)	$30/SU (Burtt 2000)
Effect of erosion on DM production (average)	10–40 kg DM/ha/year (DeRose *et al.* 1995)
Repair costs (average over all erodible land on farm)	$1500 to $5000/ha of slip face (Hicks *et al.* 1993; Krausse *et al.* 2001; Eyles 1985)
Planning horizon	20 years
Marginal tax rate	33%
Poplar planting scenarios	
Erosion prevented at 100 sph	75% from 10 to 20 years of age, straight line increase from planting to year 10. (Hawley & Dymond 1988)
Erosion prevented at 50 sph	60% from 10 to 20 years of age, straight line increase from planting to year 10. (Hawley & Dymond 1988)
Pasture production decline owing to shading	From the Green Tool Box (Luckman *et al.* 1999)
Planting costs (3 m poles, sleeves, labour)	$1500/ha @100 sph, $750/ha @ 50 sph
Gross margin (sheep only – for first 2 years after planting)	$30/SU (current), $26/SU (low)
Fodder values assumed at 5-yearly intervals	$5 to $100/ha @ 100 sph, $2.50 to $50/ha @ 50 sph, increasing as trees age, no opportunity cost for farmer time input (based on Timms 2000)
Harvest – value net of harvest and transport at 20 years	$2800/ha (50 sph), $5600/ha (100 sph) (McElwee 1998)
Silviculture	None, except for harvesting for fodder

derived in each year back to a "present value" (PV). The present value is an equivalent lump sum that would be worth as much to the farmer if received at the start of the investment period, as the full cash stream. The PV of the investment decision is then compared with the PV of retaining the *status quo*, with the difference between the two referred to as the Net Present Value (NPV). A positive NPV indicates that the investment decision is more profitable than retaining the *status quo*. This standard cost-benefit procedure was followed to evaluate the poplar investment.

A range of discount rates (5 to 10%) was used to evaluate the poplar investment decision. The "correct" discount rate is that which is closest to the best return the farmer could achieve if the money were invested elsewhere. An alternative measure is the Internal Rate of Return (IRR) of the cash stream. This represents the earning power of the capital invested, and is the discount rate that makes the NPV equal to zero (Forbes 1984).

Results

The analysis indicated that over a range of plausible scenarios, the effect of shading on dry matter production overwhelms the average erosion losses prevented by planting poplars (Table 2). The substantial cost of establishing the poplars further undermined the profitability of the investment. Harvesting of the trees was able to overcome the negative effects of the planting costs and shading losses, under some circumstances.

Table 2 Summary of results of an analysis of costs and benefits of planting poplars for erosion control.

Table 2a: Base scenario – low erosion, current GM, blanket planting, no fodder values.

	Harvest		No harvest	
	100 sph	50 sph	100 sph	50 sph
NPV @ 5%	-$86.70	-$165.17	-$1,500.79	-$872.21
NPV @ 8%	-$584.23	-$397.37	-$1,389.21	-$799.86
IRR	4.6%	3.6%	N/A*	

Table 2b: Most "favourable" scenario – high erosion, high repair costs, fodder values added, low GM, blanket planting.

	Harvest		No harvest	
	100 sph	50 sph	100 sph	50 sph
NPV @ 5%	$209.28	$58.07	-$1,204.81	-$648.97
NPV @ 8%	-$368.49	-$232.62	-$1,173.48	-$635.11
IRR	5.9%	5.5%	N/A*	

Table 2c: Targeted scenario – high erosion, high repair costs, fodder values added, current GM, targeted planting.

	Harvest 25 sph	No harvest 25 sph
NPV @ 5%	$36.76	-$316.76
NPV @ 8%	-$136.08	-$337.33
IRR	5.5%	N/A*

* IRRs are not calculable when there are no positive values in the net cash flow

Base scenario: Poplar planting was less profitable than staying with the *status quo* at discount rates over 5% under both planting densities, regardless of whether the poplars were harvested or not (Table 2a).

Most "favourable" scenario: Poplar planting was profitable at the 5% discount rate (but not at 6%) at both planting densities, provided the trees were harvested, but not otherwise (Table 2b).

Targeted scenario: Poplar planting was profitable at the 5% discount rate (but not at 6%), provided the trees were harvested, but not otherwise (Table 2c).

The relatively low profitability of the targeted planting scenario was owing to the lower number of trees harvested. Without harvesting, all scenarios had negative NPVs. This means that, given a range of plausible assumptions, the poplar investment cannot stand on the soil conservation and fodder benefits alone. Positive NPVs can be derived for the poplar planting investment over a fairly restrictive range of assumptions, all of which must be satisfied. These are discount rates of 5% or less, high erosion risk, and poplars must be harvested and sold.

Discussion

These results indicated that the profitability of poplar planting is marginal at best. Farmers evaluating a poplar planting decision could compare the results with planting radiata pine for example, which would achieve the same level of erosion prevention and generate a better return. Planting the same block of land in radiata pine is likely to return over 7% IRR at current prices (if harvesting and transport costs are not excessive), assuming no stock income, and harvesting in year 28 (Andrew Wilson, pers. comm.).

The results were remarkably insensitive to changes in assumptions for repair costs, stock gross margins and the erosion risk. While the NPVs changed slightly with changes in these variables, they remained stubbornly negative over a range of plausible assumptions. This insensitivity was owing to the relatively strong effect of shading on dry matter production. While early work considered that poplars improved pasture productivity (Hicks 1995), the assumptions underpinning the cost-benefit analysis reported on in this paper were derived from more recent research, which indicated that shading from mature poplars reduced pasture production by 20 to 30% at 50 to 100 sph (McElwee, 1998; Mackay, unpublished data). Interestingly, increases in the stock gross margins made the poplar planting decision less profitable, rather than more so, since this increased the impact of the shading losses on dry matter production.

In order to generate a positive NPV in the targeted scenario without harvesting (for example where harvesting is uneconomic) required extra annual benefits of $25 to $34 per year (at 5 and 8% respectively). Factors that could potentially make poplar planting more profitable are shelter and shade effects on livestock, and the inclusion of off-farm effects.

Space-planted poplars may lower wind speeds over the area, and provide localised shelter, especially for lambs, reducing the risk of hypothermia and death in lambs (Gregory 1995). Assuming a lamb is worth $60, if lamb losses were reduced by around 0.25 lambs per hectare by the poplars over the full life of the tree (NB, the reduction would have to be higher in the later years to compensate for the minimal shelter the trees would afford in the early years), this is enough to generate a positive NPV on the targeted/harvested scenario (at 8%).

Provision of shade in hot climates has been shown to improve reproductive performance and growth rates. The effect in New Zealand's milder climate is not currently clear. However, the animal welfare effects may be important (Gregory 1995). Some meat companies (e.g., Richmond) require the provision of adequate shade and shelter from adverse weather, in order to comply with on-farm quality assurance programmes. In some cases, compliance with all aspects of a quality assurance programme generates a premium for the farmer. Space-planted poplars contribute to the achievement of this premium.

Farmers may also gain non-monetary benefits from poplar planting, for example, a sense of stewardship, animal welfare considerations, or aesthetic improvement of the farm. In addition, risk-averse farmers may view poplar planting as a form of insurance against disastrous erosion events. Evaluation of an insurance "investment" under average conditions is unlikely to generate a positive NPV (otherwise the insurer would never make a profit), but insurance is still bought, because people are unwilling to take the risk that they may be "unlucky" relative to the average, and strike a disastrous event. Similarly, this analysis of the poplar investment assumed an average rate of erosion on all a farmer's steep land each year, rather than randomly including a severe erosion event in the cash flow. Furthermore, this analysis also did not consider the risk of an erosion event shortly after planting that results in the loss of poles before they are of any benefit in controlling erosion.

While this analysis has concentrated on the investment decision from a farmer's viewpoint, other researchers have noted that there are substantial off-site impacts from erosion (Krausse *et al.* 2001), and therefore insufficient private incentive to control erosion to the socially optimum level. In order to correct this market failure, policy makers may consider the option of funding some control measures from rates or taxes (Krausse *et al.* 2001). A positive NPV (from the farmer's viewpoint) can be generated if a subsidy is available for soil conservation. For example, under the targeted planting scenario, a subsidy of 36% of the total planting cost of $375/ha would tip the balance to a neutral NPV at 8%, assuming the trees are harvested. However, re-establishment of the poplars after harvesting may not attract a second round of subsidies. If the trees are not to be harvested, a 90% subsidy would be required to generate a positive NPV at 8%.

Conclusions

The private monetary incentives for planting poplars for erosion control are marginal at best, when the analysis is restricted to poplar's soil conservation function and fodder and timber value.

At high discount rates, and/or where the erosion risk is low to moderate, the farmer is better off staying with the *status quo*, rather than planting and harvesting poplars, unless there are strong non-monetary incentives.

At low discount rates, and where erosion risks and repair costs are high, the farmer is better off planting poplars at high densities and harvesting them, than continuing with the *status quo*. However, under these circumstances, farmers may be better off investing in pines rather than poplars.

Where harvesting of poplars is uneconomic, and/or non-monetary and insurance factors are sufficiently important to justify planting, farmers are better off targeting planting at the most erosion-prone sites, and minimising total tree numbers.

The analysis suggests that Regional/District Councils, in promoting soil conservation to farmers, need to emphasise the non-monetary and insurance benefits of poplar planting. The analysis also suggests that financial incentives may be needed to persuade farmers who are strongly profit-driven to invest in poplar planting.

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