Extension Note
BC Journal of Ecosystems and Management

Profitability of manual brushing in young lodgepole pine plantations

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Abstract

Manual brushing is an important silvicultural tool commonly used to control competing vegetation in young conifer plantations. Yet little is known about the short-term economic benefits of one versus two brushing treatments. Using forest establishment data from the Fraser Lake and Bednesti areas of the Central Interior of British Columbia, we examined the profitability of one and two applications of brushing treatments under different internal rates of return (IRR) and three brushing radii (0.75, 1.00, and 1.25 m). Our results showed that one year of brushing treatment would be profitable for almost all brushing radii since profitability required only a short reduction in cutting age and lower IRRs. Applying two consecutive years of brushing would clearly require either higher discount rates or a longer waiting period for the brushing to be profitable. We believe that the approach described in this paper will assist forest practitioners when analyzing the value of brushing in terms of return on investment over time. The economic framework will also assist forest practitioners when deciding on brush control options for young conifer plantations.

KEYWORDS: *Central Interior of British Columbia, internal rate of return, manual brushing, profitability, time gain.*

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Opio, C., K. Fredj, and B. Wang. 2009. Profitability of manual brushing in young lodgepole pine plantations. *BC Journal of Ecosystems and Management* 10(1):15–21. *www.forrex.org/publications/jem/ISS50/vol10_no1_art3.pdf*

Introduction

Forest managers endeavour to use the most effective methods to control competing vegetation in young conifer plantations. Shrubs, herbaceous plants, and deciduous trees compete for light, nutrients, and water, and potentially restrict tree growth and cause plantation failure (Opio et al. 2000, 2003; Jacob and Opio 2003). Efficacious vegetation control treatments improve conifer survival and growth by minimizing vegetative cover and future competition while causing negligible damage to crop trees (Newton and Comeau 1990). Brush control in forestry includes the following: manual brushing, chemical control, grazing, and mechanical site preparation (Baker 1998). For the forest practitioner, choice of vegetation management treatments will depend primarily upon biological and environmental factors, and secondarily on social and economic considerations. In other words, cost and profitability, while very important, are not the main criteria.

This paper focussed on manual brushing using machetes, brush hooks, handsaws, and chainsaws to cut and remove the competing vegetation (Newton and Comeau 1990). This method is commonly used in forestry because it is environmentally safe and socially acceptable (Baker 1998). Previous brushing studies in young 1- to 10-year-old conifer plantations show that manual brushing improves short-term plantation development (Hart and Comeau 1992; Simard and Heineman 1996; Opio et al. 2000, 2003); however, the studies fail to address the benefits of one versus two consecutive years of brushing treatments.

Comparing the profitability of a "new" method or treatment (e.g., one or two years of manual brushing) with that of a "standard" treatment (e.g., no brushing) typically requires considerable investment in money and time spent installing, measuring, and analyzing field studies. Moreover, assumption statements and estimation errors might affect the validity of the conclusions. As an alternative, Garcia (1996) proposed a simple economic model that eliminated the need for detailed stand information. Assuming that a "new" treatment produced a time gain (δ) or reduced the number of years to cutting age, then the break-even relative additional cost of the "new" treatment could be calculated using only internal rate of return (IRR) and δ.

The objective of our study was to illustrate a simple method for evaluating the profitability of vegetation management treatments. More specifically, we used Garcia's (1996) method to determine the break-even relative additional costs of brushing treatments in young lodgepole pine plantations in the Central Interior of British Columbia using IRR or discount rates between 0.5 and 5% and one versus two consecutive years of brushing at radii of 0.75, 1.00, and 1.25 m.

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Economic model

The break-even relative additional cost (BeRAC) provided the basis for evaluating the profitability or economic viability of the manual brushing treatments used in this study. The BeRAC was a critical value that should not be exceeded by a brushing treatment's actual relative additional cost (ARAC) for the treatment to be economically viable (Garcia 1996). This approach was appealing considering it was relatively simple and required little data. In our study we applied this approach using three main steps:

1. We calculated the BeRAC. As shown by Garcia (1996), based on the profit maximization (or cost minimization) theory, the break-even relative additional cost (BeRAC) was calculated using the internal rate of return (IRR) or discount rate (i) and the time gain (δ) as follows:

$$BeRAC = (1 + i)^{\delta} - 1 \qquad [1\}$$

2. The actual relative additional cost (ARAC) of a new treatment was calculated using the treatment's additional cost (the difference between the new total cost [$\overline{C}$] and the establishment cost [C] relative to the

value of a newly established stand (the sum of the establishment cost *C* and the land expectation value[1]

$$ARAC = \frac{\overline{C} - C}{L + C} \qquad [2]$$

3. The break-even cases or treatments yielding zero profits were those where ARAC was equal to the BeRAC. On the other hand, a treatment was considered economically viable when ARAC was less than BeRAC but unprofitable when ARAC was greater than BeRAC.

BeRAC and ARAC vary with the IRR or discount rate applied. Both IRR and discount rate are the same but the different terminology reflects the different roles of interest rate in this study. In other words, interest rate is the internal rate of return (IRR) when used to compute the break-even relative additional costs. And interest rate is the discount rate when used to discount the future value of a treatment. Since rates change with time and market conditions, we used a range of discount rates to determine how they affected the results. In reality, forest manager would use current discount rates.

Data source and application

Data

Our study focussed on young lodgepole pine plantations in the sub-boreal spruce dry warm (SBSdw) and dry cool (SBSdk) biogeoclimatic subzones of the Central Interior of British Columbia. Lodgepole pine comprises a major portion of the forested land base in British Columbia (DeLong et al. 1993) and is of considerable commercial interest. During early growth stages in the SBSdw and SBSdk, lodgepole pine is subject to adverse competition from a variety of broadleaf tree species including trembling aspen (*Populus tremuloides* Michaux) and sitka alder (*Alnus crispa* ssp. *sinuate* [Regel] Hulten) (Opio et al. 2003). Manual brushing is one of several tools used to control competing vegetation in these biogeoclimatic regions (Opio et al. 2003).

We used 2004 land expectation values and establishment and brushing costs from the Fraser Lake and Bednesti areas. Land expectation value (*L*) was $16 500 per hectare. Estimated establishment cost (*C*) was $1100 per hectare, and included $300 per hectare for site preparation and $800 per hectare for planting cost, seedlings, supervision, and snowplowing. Additional costs for one brushing treatment $\overline{C} - C$ were $300, $350, and $375 per hectare for brushing radii of 0.75, 1.00, and 1.25 m, respectively.

Model application

The first step was to use Equation 1 to calculate break-even relative additional costs (BeRAC) using IRR ranging from 0.5 to 5% and time gains of 1 to 10 years. Table 1 illustrates these critical values which represent, for each specific IRR (or discount rate) and time gain period, the relative additional cost under which brushing will be profitable and above which it will not be profitable. The results showed, for example, that for an IRR of 2% and a time gain of 3 years, a brushing treatment was profitable if its cost did not increase more than 6.012% relative to the stand value. The table also showed that if the ARAC for a brushing treatment was about 5% at a discount rate of 2.5%, the treatment must produce a time gain of at least 2 years to be economically viable.

The next step was to compute the actual relative additional costs (ARAC) using Equation 2, the data for land expectation values, and actual establishment and treatment costs. For two consecutive years of brushing, costs for the second year were discounted at rates of 0.5 to 5% when calculating the ARAC. For example, for one year of brushing at a radius of 0.75 m, the ARAC was:

$$1.70\% = \frac{300}{16500 + 1100} \times 100 \qquad \text{[Table 2A]}$$

[1] The land expectation value or net present value represents the cash flow over an infinite number of rotations of optimal length discounted at a factor of

$$\alpha = \frac{1}{1 + i}$$

where *i* is the IRR. Land expectation value can be calculated using the following formula:

$$L = \max_{t} \left\{ \frac{\alpha^t R(t) - C}{1 - \alpha^t} \right\}$$

where *R(t)* is the revenue function and *C* is the establishment cost. (For more information see Garcia 1996, Faustmann 1995, and Leuschner 1990.)

TABLE 1. Break-even Relative Additional Cost (%).The solid line shows the break-even line for one year of brushing at 1.25 m. The dashed line shows the break-even line for two years of brushing at 1.25 m.

Time Gain	Discount rate or IRR (%)									
(years)	0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0
1	0.500	1.000	1.500	2.000	2.500	3.000	3.500	4.000	4.500	5.000
2	1.000	2.001	3.002	4.004	5.006	6.009	7.012	8.016	9.020	10.025
3	1.501	3.003	4.507	6.012	7.519	9.027	10.537	12.048	13.561	15.075
4	2.002	4.006	6.014	8.024	10.038	12.054	14.074	16.096	18.122	20.151
5	2.503	5.010	7.523	10.040	12.563	15.090	17.623	20.161	22.703	25.251
6	3.004	6.015	9.034	12.060	15.094	18.136	21.185	24.241	27.306	30.378
7	3.505	7.021	10.547	14.084	17.632	21.190	24.759	28.338	31.928	35.529
8	4.007	8.028	12.063	16.112	20.176	24.254	28.345	32.452	36.572	40.707
9	4.509	9.036	13.581	18.145	22.726	27.326	31.945	36.581	41.237	45.911
10	5.011	10.045	15.102	20.181	25.283	30.408	35.556	40.728	45.922	51.140

TABLE 2A. Actual relative additional costs (ARAC) using one brushing treatment.

Radius	Actual relative additional costs (%)
0.75 m	1.70
1.00 m	1.99
1.25 m	2.13

TABLE 2B. Actual relative additional costs (ARAC) using two brushing treatments with the second-year treatment discounted over a range of rates.

	Discount rates (%)									
Radius	0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0
0.75 m	3.40	3.39	3.38	3.38	3.37	3.36	3.35	3.34	3.34	3.33
1.00 m	3.97	3.96	3.95	3.94	3.93	3.92	3.91	3.90	3.89	3.88
1.25 m	4.25	4.24	4.23	4.22	4.21	4.20	4.19	4.18	4.17	4.16

For two consecutive years of brushing at 0.75 m and at a discount rate of 1.5% for the second year's costs, the ARAC was:

$$3.38\% = \frac{300}{16500 + 1100} \times 100 + \frac{1}{1 + 0.015} \chi \frac{300}{16\,500 + 1100} \times 100\,; \quad \text{[Table 2B]}$$

In other words, one year of brushing at 0.75 m radius resulted in an actual additional cost increase of 1.70% relative to the stand value, while two years of brushing treatments increased costs by 3.38% at a discount rate of 1.5%.

The final step was to compare the ARAC (Tables 2A and 2B) and BeRAC estimates (Table 1) to evaluate the profitability of the various treatments. As a first example, one brushing treatment applied at a radius of 1.25 m resulted in an ARAC of 2.13%. The resulting break-even line (solid line in Table 1) separated the lower, profitable cases from the upper, non-profitable ones. In other words, at an IRR of 2.0%, brushing at 1.25 m would be profitable if it reduced cutting age by at least two years but unprofitable if it reduced cutting age by only one year.

When deriving the second break-even line for two consecutive years of brushing at 1.25 m (dashed line in Table 1), the discount rate for determining ARACs had to be matched with the IRR used to estimate BeRAC. Therefore, at a brushing radius of 1.25 m, and an IRR of 0.5%, the ARAC was 4.25%. This meant that two years of brushing had to reduce cutting age by at least nine years to be profitable. At a more intermediate IRR of 2.5%, the ARAC was 4.21% and the treatment had to produce a two-year time gain to be profitable.

Treatment profitability

Following two consecutive years of brushing at 1.25 m radius, a forest company will fail to make positive profits at a discount rate of 0.5% unless growth gains exceed 9 years. On the other hand, the company will profit with a growth gain of one year if the discount rate is 4.5% or higher.

Brushing radii had no effect on treatment profitability at higher IRRs; however, one or two years of brushing at 1.00 m or 0.75 m radii will improve profitability at IRRs less than or equal to 2%. In addition, at IRRs of 3.5 and 4.0%, two years of brushing at 1.25 m was profitable if it produced a two-year growth gain. However, a one-year growth gain would be profitable if the brushing radius was reduced to 0.75 m at an IRR of 3.5% and 1.00 m at an IRR of 4.0%.

Overall, comparing the break-even lines for one and two years of brushing showed that, in general, at the same radius, the profitability of two years of brushing was dependent upon higher discount rates and greater growth gains.

The concepts and principles we discussed in this paper are important. The evaluation process was relatively simple and illustrated how a theoretical economic framework can be used to successfully compare vegetation management options with limited data. We also believe that this approach will assist forest practitioners when evaluating treatment success based on return on investment over time.

Conclusions and recommendations

In this paper, we applied the break-even criterion to analyze the profitability of manual brushing of young lodgepole pine plantations in the Central Interior of British Columbia. Comparing a range of brushing radii and IRRs revealed three main points. First, one year of brushing was the most profitable treatment given growth gains of one or two years and relatively low IRRs. In other words, from an economic point of view, foresters should consider brushing young lodgepole pine plantations only once. Second, economic justification for two consecutive years of brushing would require either higher IRRs or greater growth gains. Third, IRRs significantly affect the profitability and, therefore, choice of brushing treatment.

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compare vegetation management options with limited data. We also believe that this approach will assist forest practitioners when evaluating treatment success based on return on investment over time.

We recommend the following steps when evaluating brush control options for young conifer plantations.

1. Use current discount rates (i).
2. Determine site-specific land expectation values (L) and establishment costs (C) including site preparation, planting, seedlings, supervision, and snowplowing costs.
3. Calculate actual brushing treatment costs based on brushing radius and site.
4. Examine the profitability of one and two years of brushing treatments using a range of internal rates of return (IRR) and different brushing radii.
5. Determine if the brushing treatment can be applied only once or repeated for two consecutive years.

We recommend conducting further profitability studies on manual brushing in young conifer plantations in other regions in British Columbia to gain a more comprehensive understanding of the economic benefits of brushing treatments under different locations and conditions. We expect that actual relative additional cost will vary by location and conditions in British Columbia. We also recommend that profitability studies on other brush control methods be considered to determine and compare their relative benefits with those of manual brushing. Results from such studies could provide foresters with a range of management options that can be used to effectively control brush problems in young conifer plantations.

Acknowledgements

We would like to thank Oscar Garcia for his advice on the initial steps undertaken in this study. We would also like to thank the anonymous reviewers for providing thoughtful and constructive comments on the paper.

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ARTICLE RECEIVED: **May 2, 2007**

ARTICLE ACCEPTED: **October 24, 2008**

Test Your Knowledge....

Profitability of manual brushing in young lodgepole pine plantations

How well can you recall some of the main messages in the preceding Extension Note? Test your knowledge by answering the following questions. Answers are at the bottom of the page.

1. The break-even relative additional cost (BeRAC) represents:
   - A) The critical value that a new treatment's actual relative additional cost (ARAC) should not exceed for the treatment to be profitable.
   - B) The critical value that a new treatment's actual relative additional cost (ARAC) should be equal to in order for the treatment to be profitable.
   - C) The value of the additional cost of a new treatment relative to the value of a just-established stand.

2. A brushing treatment with an actual relative additional cost (ARAC) equal to 2% can be interpreted as:
   - A) The brushing treatment results in an actual additional cost increase of 2% relative to the stand value.
   - B) The brushing treatment's actual additional cost represents 2% of the stand value.
   - C) The brushing treatment is profitable if its actual relative additional cost represents 2% of the stand value.

3. According to Table 1, a single brushing applied at a radius of 1.25 m when the discount rate is equal to 2%:
   - A) Requires at least 2 years of time gain to become profitable.
   - B) Is profitable for less than 2 years of time gain.
   - C) Is only profitable if the time gain is equal to 2 years.

Answers

1. A 2. A 3. A