Economics of Reforestation ¹

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"In spite of low economic feasibility at the firm's level, reforestation is still highly desirable from the State's viewpoint because of the indirect benefits".

Abstract

The large sums being spent annually on reforestation by provincial governments as well as the rationalization of budget planning warrant a re-evaluation of reforestation projects using economic criteria. This paper examines the direct and indirect returns from a stand of white spruce of site class I in two ways: that of present value and that of internal rate of return on the investment. The return is poor for the individual but it could increase considerably with participation by the State. Indirect benefits are sufficient to justify reforestation by the State. The allocation of reforestation costs among the various beneficiaries (the individual, federal, provincial and municipal governments) should be made in direct proportion to the benefits received. The State has a great responsibility in reforestation because of the long production period of the forests.

Considérations économiques sur le reboisement

Résumé

Les sommes élevées que les gouvernements provinciaux investissent annuellement dans le reboisement ainsi que la rationalisation des choix budgétaires nécessitent une réévaluation des projets de reboisement à partir de critères économiques. Cet exposé analyse la rentabilité directe et indirecte d'une plantation d'épinette blanche de qualité de station 1 à l'aide de deux méthodes: celle de la valeur présente nette et celle du taux interne de rendement sur l'investissement. La rentabilité est faible pour l'individu mais elle peut être accrue considérablement surtout par la participation de l'Etat. Les bénéfices indirects sont suffisants pour justifier le reboisement par l'Etat. Le partage des coûts du reboisement devrait être fait par les différents bénéficiaires (individu,

gouvernements fédéral, provincial et municipal) au pro rata des bénéfices perçus. L'Etat a une grande responsabilité dans le reboisement à cause de la longue période de production en foresterie.

Introduction

The large amounts of money being invested annually by provincial governments and the increasing budgetary constraints call for a reevaluation of reforestation projects from economic criteria. According to a study, there are in Quebec 1.5 million acres of land available for reforestation; this figure excludes 3.5 million acres of marginal forest land. In order to justify the actual and future expenditures on reforestation, and to analyse the opportunities available for reforestation, government must take into account the direct and indirect costs and benefits of reforestation. Some of the questions that government is asking himself are the following ones:

- 1—What are the establishment costs of a plantation?
- 2—What are the physical yields of a plantation during thinnings and final harvest?
- 3—What is the rate of return on investment in a plantation under a given set of assumptions about selling price, cost of production, and technology? More precisely, is reforestation economically feasible for the firm, the government, and society as a whole?
- 4—How much can government afford to invest in reforestation, either for purchasing land, or for silvicultural treatments?
- 5—How should reforestation costs be allocated among governments and private enterprise?

Furthermore, the growing concern of State for reforestation also stems from the necessity of a continuous timber supply for forest industries. Many rural areas in the province of Quebec are economically characterized by low income and under-employment. In those areas, because of scarcity of capital, promotion of development projects has to be done in such a way as to take full advantage of natural resources to improve local economy. The forest is the major natural resource in Quebec.

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Investments in this resource for reforestation purposes can increase timber production and generate income.

Purpose of this paper

The purpose of this paper is to demonstrate, with an hypothetical example, the economic feasibility of reforestation. This will answer some of the previous questions.

Methodology and source of data

Two economic models will be used to show the feasibility of reforestation: the first one is based upon the net present value of all costs and revenues during the first rotation; the second one is based upon the internal rate of return upon investment, that is, the interest rate for which the present value of (i) establishment costs, (ii) total annual costs of protection, taxation, and administration, and (iii) thinning costs and final harvest costs, is equal to the present value of all anticipated revenues during the rotation.

Feasibility calculations consider two aspects: (i) the biophysical aspect, that is the physical input-output relationship (production function) concerning the volume increments resulting from thinnings (yield table), and (ii) the economic aspect which involves the value of inputs and outputs, that is, production costs (salaries, equipment, interest rate), and selling price.

Other characteristic of the methodology is the choice of the rotation period as the basis for calculations. Because reforestation costs are incurred at the beginning of the rotation and because anticipated revenues are realized towards the end of the rotation, it is necessary to use the rotation period as the time unit basis.

The methodology followed in this paper to calculate the feasibility of reforestation is similar to the one used by most authors (2, 7, 13, 14).

Feasibility calculations are based upon a certain number of assumptions concerning physical yields, costs, revenues and technology. These assumptions will be defined all along the text. Data on yields from thinnings and final harvests and also data on silvicultural treatments program were provided by Professor Vezina at Laval University; these data have already been used in a paper presented by a student (3) at the School of Forestry at Laval University, paper in which I have participated technically. Some of the data on production costs are borrowed from this paper; while others are drawn from an unpublished report prepared by the Restauration service of the Quebec Department of Lands and Forests. Two other reports submitted to the department (6, 12) were also used as sources of data.

Establishment costs and annual expenditures of a plantation

Establishment costs of a plantation include the purchase of land, permanent improvements, the purchase of seedlings, plantation costs and weeding costs.

To these costs, one has to add annual costs of protection, taxation and administration. Table 1 shows the average costs of establishment of a plantation and also the annual costs. Table 2 indicates the present value of establishment costs of a plantation, and also the present value of annual expenditures incurred during a 70 year rotation; these present values are expressed in terms of different interest rates.

The costs of land and permanent improvements $(1+p)^n-1$ are multiplied by the following factor: $\frac{1}{(1+p)^n}$

because these costs cannot be imputed to only one rotation; indeed, at the end of this period, the land and permanent improvements still have a value². It is assumed that annual expenditures will increase at the rate of 15 percent per decade.

Table 1 Average establishment costs and annual expenditures of a plantation, Quebec.

Items	Average cost \$/acre
Purchase of land.....	10.00
Permanent improvements.....	10.00
Purchase of seedlings***.....	0
Planting (mechanical).....	30.00
Weeding (mechanical planting).....	4.00
Total establishment costs.....	54.00
Protection (acre/year).....	0.08
Annual taxes.....	0.45
Administration and supervision (acre/year).....	0.50
Total annual expenditures.....	1.03

²Symbols "p" and "n" respectively show the discount rate and the number of years.

³***The cost of seedlings is left out only in the calculations at the firm's level because State provides them free. This cost usually rises to \$20.00 per thousand seedlings, that is, to \$20.00 per acre

Table 2 Present value of establishment costs and of annual expenditures of a plantation, for a 70 year rotation

Items	Present value of plantation costs at different interest rates (p. 100)				
	2	4	6	8	10
	\$/acre				
Purchase of land.....	7.50	9.36	9.83	9.96	9.99
Permanent improvements.....	7.50	9.36	9.83	9.96	9.99
Planting (mechanical)...	30.00	30.00	30.00	30.00	30.00
Weeding.....	4.00	4.00	4.00	4.00	4.00
Total establishment costs.....	49.00	52.72	53.66	53.92	53.98
Annual expenditures.....	88.97	55.45	38.83	24.49	23.70
Total (excluding seedlings).....	137.97	108.17	92.49	83.41	77.68
(including seedlings)	159.97	128.17	112.49	103.41	97.68

Physical yields of a plantation

Before calculating the economic feasibility of a plantation, one must estimate not only costs but also physical yields and revenues. Revenues result from thinnings and final harvest. Table 3 shows the physical yield of a white spruce plantation of site, class I.

It is assumed that a thinning will be made every 10 years, starting at the age of 30 years. The final harvest time is 70 years. Total output is expected to be 71 cunits, 29 of which are released by thinnings.

Table 3 Physical yields of a white spruce plantation, site class I, 70 year rotation

Items	Age of stand in years	Average volume in cunits/acre			Cumulative cut	Total production
		Before cut	Cut	After cut		
Thinning.....	30	15.5	4.0	11.5	4.0	15.5
Thinning.....	40	27.5	7.5	20.0	11.5	31.5
Thinning.....	50	36.0	7.5	28.5	19.0	47.5
Thinning.....	60	42.0	10.0	32.0	29.0	61.0
Final harvest.....	70	42.0	42.0	0	71.0	71.0

Table 4 Present value of direct and indirect revenues from a white spruce plantation of site class 1, Quebec.

Items ⁴	Volume of cut in cunits/acre	Selling price in \$/cunit	Present value of direct revenues in \$/acre at different interest rates				
			2	4	6	8	10
T ₃₀	4.0	5.24	11.57	6.46	3.65	2.08	1.20
T ₄₀	7.5	6.71	22.79	10.48	4.89	2.32	1.11
T ₅₀	7.5	8.59	23.94	9.07	2.50	1.37	0.55
T ₆₀	10.0	11.00	33.52	10.46	3.33	1.09	0.36
H ₇₀	42.0	28.16	295.71	75.95	20.02	5.41	1.50
Present value of direct revenues			387.53	112.42	35.39	12.27	4.72
Present value of indirect revenues.....			1786.32	554.83	189.21	71.16	29.61
Present value of all revenues.....			2173.85	667.25	224.60	83.43	34.33
Present value of costs (including seedling costs)			137.97	108.17	92.49	83.41	77.68
(including seedling costs)			157.97	128.17	112.49	103.41	97.68

⁴*Symbol "T" means thinning and symbol "H" means harvest. The subscript represents the year of treatment.

Direct and indirect revenues from a plantation

Calculations of direct revenues are based upon the assumption that the selling price of stumpage is \$2.50 per cunit in the case of thinning and \$5.00 per cunit in the case of final harvest; the annual increment of this price is assumed to be about 2.25 per cent per year (Appendix 2). The indirect revenues, estimated at \$18.63/cunit when processed in the newsprint industry (6), include (i) companies profits taxes, (ii) other contributions to federal provincial and municipal governments, that is, income taxes, contributions to the Rental Board by individuals and entrepreneurs, contributions to the Labor Accidents Commission, contributions to the Unemployment Insurance Commission, sale tax, school and municipal taxes, other contributions and finally contributions generated in other industries because of the multiplier effect.

It is assumed that indirect revenues will increase at a rate of 2.5 per cent per year (Appendix 3). These benefits exclude those from recreation, and water and soil conservation. Table 4 shows the present value of direct, indirect, and total revenues from the plantation; these values are given in terms of different interest rates.

Direct and indirect feasibility of a plantation Net present value method

According to Table 5, from the individual viewpoint, the net present value of investment is positive at 4 percent discount rate, but becomes negative at 6 per cent. This implies that, at 4 per cent, investment in reforestation, not only generates income enough to pay for 4 per cent interest charges, but also creates an additional income of \$4.25 per

Table 5 Net present value of a white spruce plantation, site class I, Quebec.

Items	Present value of revenues ^a in \$/acre at different interest rates (p. 100)				
	2	4	6	8	10
Net present value of direct benefits.....	249.56	4.25	-57.10	-71.14	-72.96
Net present value of direct and indirect benefits ex. seedl. (incl. seedlings)	2035.88	559.08	132.111	0.02	-43.35
	2015.88	539.03	112.11	-19.98	-63.35

acre; this income, when compounded at the rate of 4 per cent, will amount to \$66.17 at the end of the rotation period. For the State, the net value based upon direct and indirect benefits is much higher than the firm's one; this value becomes zero at about 8 per cent. This rate is very conservative.

Internal rate of return method

The rate of return on investment (calculated graphically) in the white spruce plantation is 4.2 per cent for the firm and 8 per cent for the State. It looks as though planting white spruce is not much feasible economically for the individual firm, but this feasibility can be largely increased by State's contribution and by an appropriate choice of silvicultural treatment, of species and best sites.

Conclusion

The economic feasibility of a plantation may vary

between 4 and 6 percent for the firm. Given the actual money market conditions characterized by high interest rates, this rate of return is low.

Furthermore, the use of monetary yield to evaluate the economic desirability of a reforestation project has serious limitations because forests produce not only timber but also other goods and services. The economic feasibility of reforestation as calculated in this paper is based on a specific set of assumptions concerning physical yields, costs, and revenues. The 4 per cent rate of return found in this paper is rather conservative if one considers that most reforestation projects in the world have a rate of return of 6 or 7 per cent (11). Feasibility from the firm's viewpoint can be largely increased mainly by State's support.

In spite of low economic feasibility at the individual or the firm's level, reforestation is still highly desirable because of indirect benefits associated with multiple use such as recreation and soil and water conservation. Reforestation allows forests to maintain their role in economic development. Indeed, in our country, forestry is a sector the substantial comparative advantages of which contribute to development in many ways. Firstly, this sector provides a large number of consumption products and intermediate products used in many sectors of the economy so that forward and backward linkages effects are considerable. Secondly, forest industries are based upon a renewable resource and they vary greatly in their technological and production factors requirements. Thirdly, forestry is a source of employment, income and foreign currencies.

At the State's level, the rate of return of 8 percent is conservative and could reach 25 percent and 30 percent (6).

Planting seedlings for Christmas tree production is one of the various ways to improve the economic feasibility of reforestation because it allows more rapid revenues. Finally, reforestation costs should be shared by all beneficiaries (individuals, federal,

provincial and municipal governments) in proportion of the accrued benefits.

Appendix I — Annual expenditures of a plantation based upon an initial charge of \$1.03 increasing at the rate of 5 percent per decade.

Years	Annual expenditures in dollars per acre
0—10.....	1.03
10—20.....	1.18
20—30.....	1.36
30—40.....	1.56
40—50.....	1.79
50—60.....	2.06
60—70.....	2.37

Appendix II — Expected selling prize of stumpage rising at the rate of 2.5 percent per year.

Years	Selling price in dollars / cunits	
	Thinning	Harvest
1970.....	2.50	5.50
2000.....	5.24	—
2010.....	6.71	—
2020.....	8.59	—
2030.....	11.00	—
2040.....	—	28.16

Appendix III — Indirect benefits predicted according to a rate of increase of 2.5 percent per year.

Year	Indirect benefits in dollars per cunits
1970.....	18.63
2000.....	39.08
2010.....	50.02
2020.....	64.03
2030.....	81.97
2040.....	104.93

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