ECONOMIC ANALYSIS OF THREE REGENERATION ALTERNATIVES IN MAINE'S SPRUCE-FIR FOREST [1]

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ABSTRACT

This study investigates three regeneration regimes using the net present value criterion and mill delivered cost per cord. These three systems are: (1) tree-improvement programs for Japanese larch (Larix leptolepis (Sieb. and Zucc.) Gord.); (2) natural spruce-fir precommercially thinned at ten years; and (3) a natural spruce-fir stand unmanaged. Real discount rates, percent of gain in volume because of the program used, and real increases in the value of the pulpwood (mill delivered price) were varied for sensitivity analysis. The net present value criterion indicated at what year the stands should economically be harvested. Results indicated that as discount rates increased, economic rotation length decreased. Percent volume gain had little effect on the rotation length. Real increase in mill delivered prices however, did affect rotation length.

INTRODUCTION

The U.S. Department of Agriculture predicts a softwood pulpwood shortage in the U.S. of 33.3 million cords by the year 2000 (U.S.D.A. 1982). Field (1980) reported in a survey conducted among Maine's pulp and paper industries, that an increased demand on the spruce-fir resource of 1,294,000 cords could exist by 1990. Maine is presently experiencing a major spruce budworm (Choristoneura fumiferana (Clem.)) defoliation which is especially severe in the 50 to 70 year age class. This class composes 54% of all spruce-fir acreage in Maine today (Maine Forest Service, 1983). A serious shortage of softwood pulpwood could occur in Maine by 1990 if some type of silvicultural management is not initiated for Maine's 7.7 million acres of spruce-fir.

This report is part of a larger study conducted to economically analyze six possible regeneration regimes that could be applied to Maine's spruce-fir forests. Three of these regimes will be discussed in this paper. Cost-benefit analysis was used to perform economic sensitivity analysis of these regimes. The net present value criterion was used because of its ease in application and interpretation. This criterion takes each future cost, discounts it back to present at some specified discount rate, does the same to benefits (in this case the value of the wood harvested) and subtracts the initial costs and discounted

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costs from the discounted benefits (Brewer, 1971):

$$NPV = \frac{B1-C1}{(1+d)^{1}} + \ldots + \frac{Bn-Cn}{(1+d)^{n}} - Co$$

d = discount rate
B = benefits
C = costs
Co= initial costs
n = number of periods

If the result is positive this regime is capable of paying for itself (making money at that specific discount rate). This study used three different discount rates to provide a range of alternatives for the decision making process. Row et al. (1981) reported a 4% real discount rate was realistic for the evaluation of federal forestry investments. Since private investors normally expect higher rates, we used real discount rates of 5.8%, 8.7% and 12% in this analysis. Anothe economic parameter that was varied was the real increase in the mill delivered price of the wood. This price incorporates any savings that the harvest and trans port in managed stands would incur. For this reason mill delivered price rather than stumpage price was used. The U.S. Department of Agriculture predicts real increases in northern softwood pulpwood of 1.5 to 2% per year (U.S.D.A. F.S. 1973) Three rates were used in this analysis: 1%, 2%, and 4%. Table 1 summarizes these economic parameters.

Tree improvement programs and precommercial thinning have the primary objective of increasing the merchantable yield of wood per acre. To incorporate the added volumes of these programs, a range of volume percentage increases were used. Table 1 provides these rates of increase for Japanese larch and thinned spruce-fir. The values for Japanese larch are based on volumes reported by Stairs (1965) and Vallee and Stipanicic (1983). Merchantable yield tables provided by Stone (1957) were adjusted by different percentages to give increased merchantable yield tables reflecting tree improvement programs in Japanese larch. Ker (1981) achieved up to a 15% increase in volume from precommercially thinning trials of overstocked stands of natural spruce-fir stands in New Brunswick. Secondary data for other costs was used for input into Vasievich and Frebis (1982) Forestry Investments Analysis Program. Table 2 summarizes these inputs. The selection and orchard costs for Japanese larch are on a per acre basis for the clone orchard. These costs were amortized over the life of the orchard (20 years) and distributed among an assumed 20,000 acres of plantations per year. The other costs are on a per acre basis for the plantations. The output values from this program were net present value and total present cost. The net present values were plotted over rotation lengths. Figures 1 and 2 for Japanese larch illustrate these curves for different discount rates and increases in mill delivered price. The total cost was divided by the cords produced per acre to determine the cost per cord of each program. Figure 3 shows these results for Japanese larch, at a 5.8% discount rate. Cost per cord of programs decreased over time, and also decreased with respect to each increasing discount rate.

One objective of this study was to determine the economic rotation length of each program, given the economic and silvicultural parameters. This economic rotation length was determined where the net present value curve reached its greatest positive or least negative value. This rotation length was then used to enter the cost per cord curve to determine the optimum cost per cord for that program. Tables 3, 4 and 5 summarize the optimums reached for each of the three regimes analyzed in this paper.

RESULTS

The general trends noted in this study were as follows: (1) as the discount rates increased (at each level of increased mill delivered price), the economic rotation lengths decreased (2) with increasing discount rates the difference in net present value decreased between the improvements in volume specific to each regime, (3) though the degree of improvement had little appreciable affect on the economic rotation, it did increase the net present value achieved at the economic rotation age, and (4) as the mill delivered price increased the net present values increased and the economic rotation lengths increased.

The economic rotation lengths decreased with increasing discount rates because the higher the discount rates, the more drastic the affect on discounted costs and benefits, forcing an earlier economic rotation age to maximize net present value. In Table 4 for natural spruce-fir thinned, note that at a 1% increase in mill delivered price, a 5.8% discount rate provided an economic rotation length of 58.5 years, which decreased to 41.5 years at 8.7% and 30 years at 12%. A potential problem with this type of analysis is that sometimes the economic rotation length may not be biologically possible for that system. The natural spruce-fir (thinned) at 30 years of age would provide less than 6.6 cords/acre but have a dbh of less than 5 inches. This dbh is not acceptable to most companies.

The financial advantage of improved volumes decreased as the discount rates increased. For Japanese larch at a 5.8% discount rate and 1% increase in mill prices, the difference in value between 30% and 0% improved volumes was $21.50 (Table 3). This difference decreased to $7.70 for an 8.7% discount rate and to $2.76 for a 12% discount rate. Conversely, as the mill delivered price increased, volume increases became more valuable and the economic rotation length increased, at all discount rates. For example, the 30% increase in volume which had an added value of $21.50 given a 1% increase in prices (at a 5.8% discount rate) is worth $69.00 if prices increase at the rate of 2% per year, and is worth $387.89 given a 4% increase in prices. The economic rotation length in this example increased from 29.5 years at a 1% increase in mill delivered price to more than 50 year at a 4% increase in price. These economic rotation lengths are based solely on optimization of net present value; in actual practice, biological factors such as changes in wood quality would probably dictate the use of shorter rotations in Japanese larch.

It can be seen from Table 2 that the cost of producing improved seedlings is only $0.20 per acre planted greater than for unimproved seedlings, if the tree improvement costs are distributed over 20,000 acres planted per year and over the 20-year life of the orchard. Tree improvement costs are insignificant in comparison to the costs of seedling production, planting, and site preparation. Any reductions possible in those costs of establishment would have a major impact on net present value. For example, if harvesting were carried out in such a way as to eliminate the need for site preparation, net present values would be increased by $40.00 per acre.

CONCLUSIONS

Both Japanese larch tree improvement programs and precommercial thinning of overstocked spruce-fir stands could provide positive net present values at a 2% increase in mill delivered price and 5.8% discount rate. At a 15% increase in volume the managed spruce-fir would have a net present value of $42.00/acre; at the 30% improvement the Japanese larch would have a $137.00/acre value; while the unmanaged spruce-fir at a 5.8% discount rate is worth $11.50/acre. These net present values are based on one acre production, and would increase considerably for more acres managed. Managed stands (either precommercially thinned spruce-fir or superior seed plantations) should be closer to the mill to minimize transport costs and maximize the net present value (through cost minimization). Silviculturally managing the forest can provide maximum merchantable volume in a minimum amount of time. With potential rotation lengths of 20 to 40 years, possible softwood pulpwood shortages in the future could be met. Tree improvement programs could be established for species conversion and precommercial thinning could be conducted in overstocked young spruce-fir stands. Both systems have proved economical at a 2% increase in mill delivered price and 5.8% discount rate. Unmanaged spruce-fir is the least productive regime in net present value and in cost per cord.

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Table 1. Economic and Silvicultural parameters applied in net present value analyses.

Range of Economic Parameters:					
Discount Rates	5.8%		8.7%		12%
Increase in Mill Delivered Price	1%		2%		4%
Range of Anticipated Merchantable Volume Increases:					
Japanese Larch Tree Improvement	0%	5%	10%	20%	30%
Natural Spruce-fir Thinned at 10 Years	0%	5%	10%	15%	
Natural Spruce-fir Unmanaged	0%				

Table 2. Summarized input data for three regeneration regimes.

Regime	Expense	Year Incurred	Cost/Acre+	Percent Annual Cost Increase
	Annual Tax	*	1.36	2
	Management	*	1.50	1
Japanese larch (21 years, 10% i.v.)	Selection	0	908.53	0
	Orchard Est.	3	1600.83	0
	Maintenance	3	172.31	1
	Controlled Pol.	7	312.21	0
	Nursery Prod.	12	468.32	0
	Progeny	14	936.44	0
	Cost/1000 seed		0.29	
	Seedling Prod. (681 t/a)			
	improved	10	102.35	0
	unimproved	10	102.15	0
	Planting	11	38.83	0
	Site Prep	11	40.00	1
	Harvest	32	737.76	1
	Revenue	32	1019.90	1
Natural spruce-fir (30 years, 10% i.v.)	Thinning	21	125.00	1
	Herb. Treat.	25	40.00	1
	Harvest	41	223.83	1
	Revenue	41	393.85	1
Natural spruce-fir (20 years)	Harvest	31	182.83	1
	Revenue	31	282.10	1

* indicates annual cost

\+ costs are per acre of plantation except for Japanese larch selection and seed orchard costs, which are given per acre of orchard.

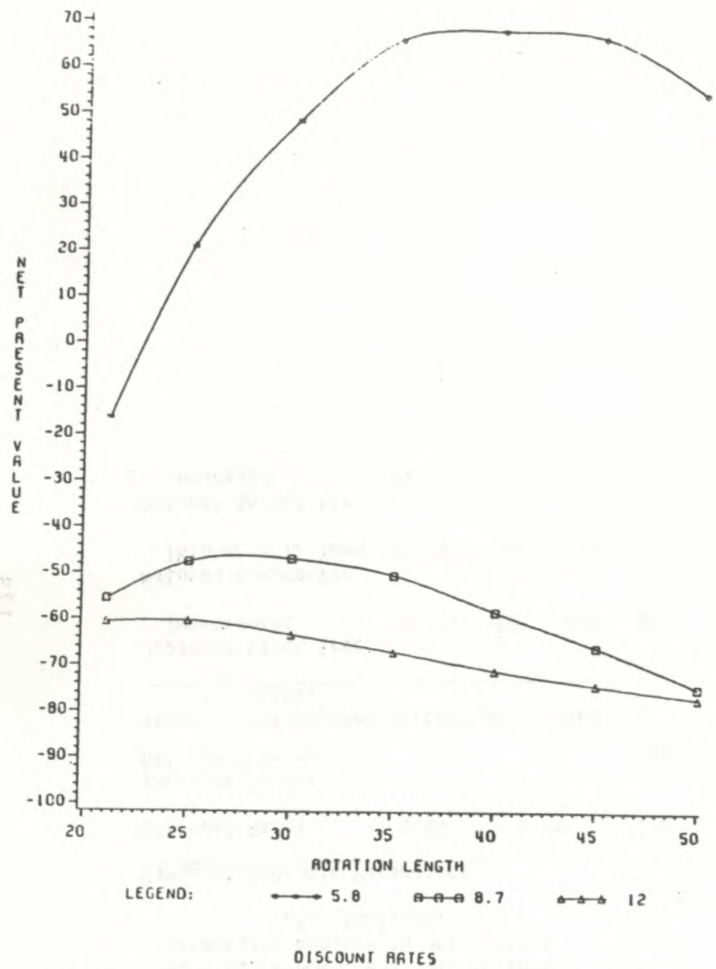

Figure 1. Net present value for Japanese larch at three discount rates, given a 2% annual increase in mill delivered prices and 0% improvement in volume.

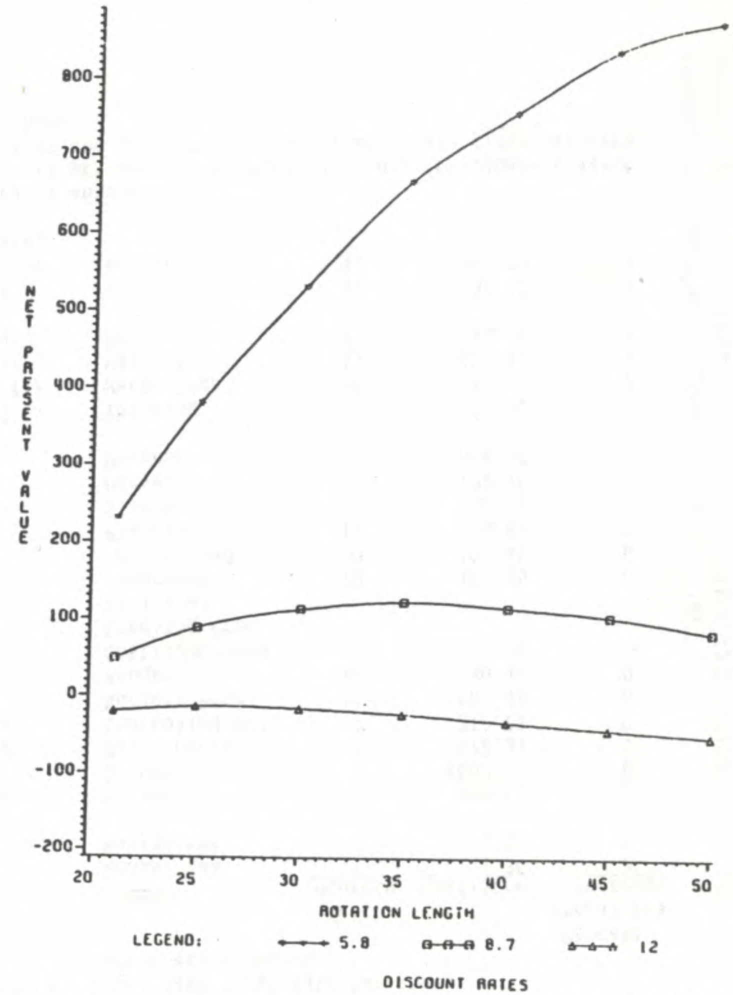

Figure 2. Net present value for Japanese larch at three discount rates, given an 4% annual increase in mill delivered prices and 0% improvement in volume.

Table 3. Optimum economic rotation length results for Japanese larch

Mill Delivered Price Increase 1%

D.R.	I.V.	NPV	Rotation Length	$/Cord
5.8%	30	-62.50	29.5	8.20
	10	-77.00	28.7	8.50
	0	-84.00	28.5	8.60
8.7%	30	-80.00	24.0	5.50
	10	-85.10	24.0	6.10
	0	-87.70	24.0	6.50
12%	30	-70.50	20.0*	4.05
	10	-72.39	20.0*	4.58
	0	-73.26	20.0*	4.93

Mill Delivered Price Increase 2%

D.R.	I.V.	NPV	Rotation Length	$/Cord
5.8%	30	137.00	37.5	5.20
	0	68.00	38.5	6.00
8.7%	30	-25.00	27.2	4.35
	0	-46.00	27.5	4.95
12%	30	-55.00	23.5	3.15
	0	-61.00	23.0	4.12

Mill Delivered Price Increase 4%

D.R.	I.V.	NPV	Rotation Length	$/Cord
5.8%	30	1265.82	50.0+	3.42
	0	877.93	50.0+	3.89
8.7%	30	200.00	35.0	2.73
	0	120.00	35.0	3.24
12%	30	0.00	27.5	2.31
	0	-15.00	26.4	3.08

+ indicates curve still increasing

* indicates optimum point reached before initial rotation age.

Table 4. Optimum economic rotation length results for natural spruce-fir thinned.

Mill Delivered Price Increase of 1%

D.R.	I.V.	NPV	Rotation Length	$/Cord
5.8%	15	-68.00	58.5	3.60
	10	-70.50	58.5	3.70
	0	-75.30	58.5	4.00
8.7%	15	-63.00	41.5	3.65
	10	-63.50	41.5	3.80
	0	-64.50	41.5	4.20
12%	15	-43.95	30*	6.67
	10	-44.82	30*	6.96
	0	-45.04	30*	7.61

Mill Delivered Price Increase of 2%

D.R.	I.V.	NPV	Rotation Length	$/Cord
5.8%	15	42.00	54.0	4.30
	0	18.20	50.0	5.32
8.7%	15	-43.00	46.2	2.60
	0	-42.00	39.5	5.18
12%	15	-41.50	40.0	2.34
	0	-47.00	46.0	1.65

Mill Delivered Price Increase of 4%

D.R.	I.V.	NPV	Rotation Length	$/Cord
5.8%	15	700.00	64.5	3.15
	0	583.00	71.0	3.10
8.7%	15	60.00	51.5	2.19
	0	40.00	50.0	2.47
12%	15	-30.00	43.0	1.75
	0	-38.00	44.5	1.50

* indicates optimum point reached before initial rotation age.

Table 5. Optimum economic rotation length results for natural spruce-fir unthinned.

Mill Delivered Price Increase of 1%

D.R.	I.V.	NPV	Rotation Length	$/Cord
5.8%	0	-28.20	20	18.40
8.7%	0	-28.20	20*	10.47
12%	0	-25.10	20*	7.04
Mill Delivered Price Increase of 2%				
5.8%	0	11.50	34	9.30
8.7%	0	-17.50	25	8.20
12%	0	-21.00	20*	7.00
Mill Delivered Price Increase of 4%				
5.8%	0	237.00	55	5.20
8.7%	0	30.00	33	5.00
12%	0	-7.50	23	5.90

*indicates optimum point reached before initial rotation age.

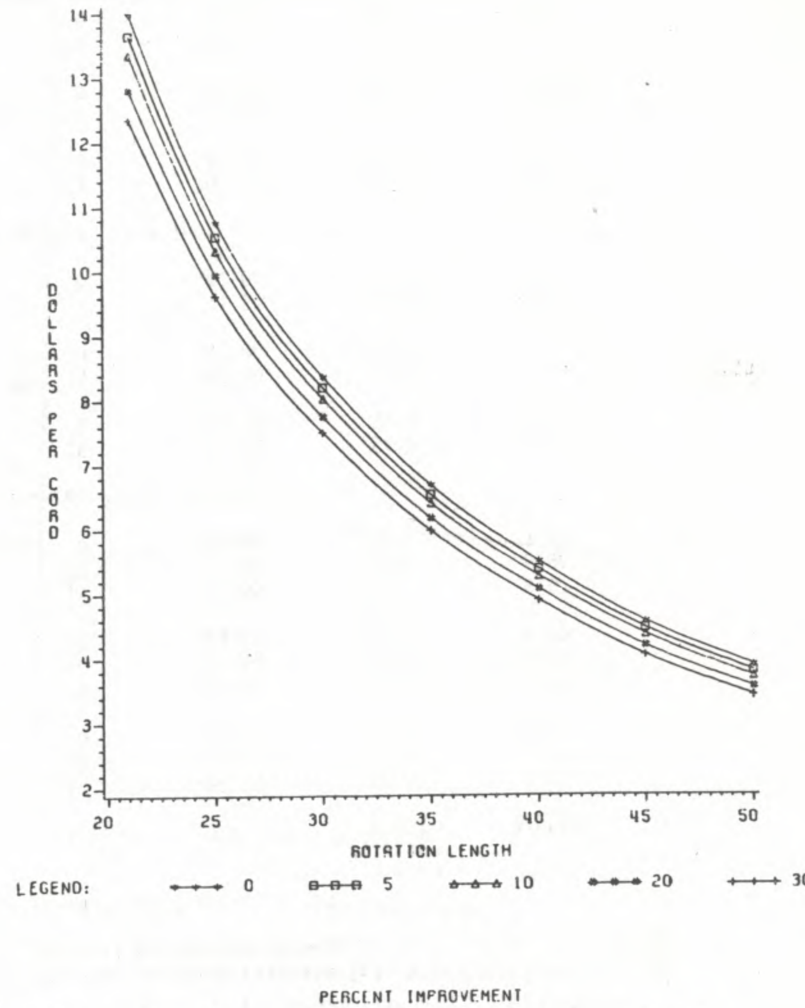

Figure 3. Cost per cord for Japanese larch given 1% annual increase in mill delivered price, 5.8% discount rate, and five levels of genetic improvement in volume.