ECONOMIC ANALYSIS IN PLANNING THE MINNESOTA DEPARTMENT OF NATURAL RESOURCES TREE IMPROVEMENT PROGRAM[1]

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__Abstract.__ Discounted cash flow benefit-cost analyses were carried out for forty-one different program options as a part of a 1982 revision of the Minnesota tree improvement plan. These analyses, along with revised estimates of future seed needs and feedback from the field, resulted in modifications of program plans. Greater emphasis will be placed on aspects of jack pine improvement and the development of white pine and black walnut clonal orchards while activities related to the improvement of white spruce, black spruce and red pine will be reduced. This paper illustrates the role cash flow analysis played in these revisions.

The Minnesota Department of Natural Resources, Division of Forestry, is the state's dominant producer of planting stock and probably will hold this position far into the future. The organization distributed over 21 million tree and shrub seedlings in 1982 and its nursery production is expected to reach 48 million seedlings per year by the turn of the century (MN DNR 1983).

In order to insure the quality of the stock it distributes, the Division of Forestry has initiated a tree improvement program with the goal of increas-in the productivity of public and private forest lands in Minnesota through the use of genetic principles. The first formal plan for this program was developed jointly by DNR and University of Minnesota, College of Forestry personnel. This plan, designed to provide a framework for DNR tree improvement activities through the year 2000, was drafted in 1980 and published in 1981 (MN DNR 1981).

The planning process consisted of establishing species priorities, evaluating approaches to the improvement of high priority species, selecting the most promising of these approaches and constructing a tentative schedule of program implementation. Planning of this large multi-species program was characterized by uncertainty because of our limited experience in applied improvement work and an, incomplete data base. As a result of this uncertainty, the need for frequent review and updating was recognized. The first review and revision of the plan occurred in 1982, partly as a result of legislative direction provided by the Minnesota Forest Resources Management Act of 1982.

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The 1982 revision utilized new or updated information from a number of sources. Major inputs were a revised estimate of future seed needs for the state's reforestation programs, and feedback on operational and biological problems from those who were implementing the program. In addition, a series of discounted cash flow benefit-cost analyses was completed and the results used in evaluating program alternatives. These analyses and their use in planning are discussed below.

THE CASH FLOW ANALYSES

General. An acknowledged weakness in the inital plan was the use of subjective methods to establish species priorities and to allocate resources to the various components of the program. While the desirability of allocating resources in proportion to the expected returns was recognized in 1980, no objective economic criteria were available. The 1982 series of discounted cash flow analyses represents a first attempt to develop measures of investment performance for the components of the tree improvement program.

The cash flow analyses involved the enumeration of returns and costs over time for each prospective component of the program and then discounting these values to a common point in time (i.e., the year work began = year 0 = 1982). The discounted values were then used to compute common investment performance measures. These measures included net present value, internal rate of return (discount rate at which net present value = zero) and the benefit-cost ratio. The predetermined discount rate used was 4.4 percent which represents the minimum real rate of return the Division of Forestry is willing to accept from its investments. Since all inputs were in 1982 dollars, the general inflation rate was not a factor.

A total of forty-one analyses of potential components of the tree improvement program was completed. A component was defined as a specific-activity at a given level with a particular species which would lead to the genetic improvement of the planting stock. Activities fell into the following general classes: (1) control of seed source; (2) establishment of seed production areas; (3) development of first generation seed orchards (seedling and clonal); and (4) creation of advanced generation seed orchards. Analyses dealt with the six highest priority species in the nursery program: red pine, jack pine, white pine, white spruce, black spruce and black walnut.

The number of analyses per species varied. Only those species-activity combinations which were judged to be practical alternatives for the DNR program were examined. In some species variations in the techniques used to implement an activity defined components (i.e., containerized vs. nursery production of seedlings) and in others several levels of implementation (i.e., 10 vs. 20 vs. 30 acres of seed orchard) were considered. Space does not permit descriptions of species-activity components and the rationale for their selection. In general, standard tree improvement approaches with modifications to meet the DNR's needs were considered. Table 1 provides a summary of those evaluated by cash flow analysis.

Table 1. Summary of species - activity combinations and levels of activity evaluated using cash flow analyses,

Program Component	red pine	jack pine	white pine	white spruce	black spruce	black walnut
	(level of activity or acres of installation)					
Source Control	complete	complete	---	complete	complete	---
Seed Prod. Areas	100 ac. 200 ac.	---	---	40 ac.	---	---
Seed Orchards						
1st gen. grafted	---	---	5 ac.	20 ac. 30 ac. 40 ac.	---	5 ac.
1st gen. seedling (nursery stock)	25 ac. 50 ac. 75 ac.	16 ac.	---	---	3 ac.*	---
1st gen. seedling (container stock)	25 ac. 50 ac. 75 ac.					
2nd gen. (open-pollinated)	---	10 ac. 20 ac. 30 ac.	---	20 ac.	8 ac.* 16 ac.*	--- ---
2nd gen. (control-pollinated)	---	10 ac. 20 ac. 30 ac.	---	20 ac.	8 ac.* 16 ac.*	---

*all black spruce analyses run for three levels of production of plantable seedlings per unit of seed.

Actual analysis was done on the University of Minnesota's Cyber computer system using an interactive program developed by DNR and U of M Forest Economists. The analyses were relatively simple to conduct and the costs of processing were modest. However, the initial development of cost and benefit data for input presented a more complex problem.

Cost Values. Costs for a specific program component were estimated by listing for each year of the project all activities necessary for implementation. This listing covered the period from the time the work was planned to the last year the component provided seed for the nursery. Every effort was made to make this listing as complete as possible. A condensation of the listing for a program component of 16 acres of first generation jack pine seedling seed orchard is found in Table 2.

Table 2. A condensed listing of cost items by year and real rates of cost increase for 16 acres of first generation jack pine seedling seed orchards 400 families.

Year	Activities	Cost increase above general inflation rate
0	Planning - problem analysis, research and writing	2.6
1	Selection - training, field work, record keeping	2.6
1	Seed acquisition - cone collections, seed extraction, record keeping, etc.	2.6
2	Nursery - bed preparation, sowing, culture, record keeping	2.6
3	Site preparation - selection	2.6
3	Site preparation - equipment operation	3.0
4	Site preparation - laying out	2.6
4	Materials preparation - measurements, lifting, labeling, sorting and record keeping	2.6
4	Planting -	2.6
4	Mapping -	2.6
5 & 7	Chemical and weed control	5.4
8 & 9	Mechanical weed control	2.6
8 - 24	Fertilization	5.4
8 - 24	Mowing	3.2
10 & 15	Measurements and analysis	2.6
11 & 15	Marking and thinning	2.6
12 - 24	Seed collection	2.6

After these listings were completed, costs were assigned to each item. If an item could be equated to a normal DNR forestry activity, costs obtained from DNR records were used. Listings in this category were greenhouse heating, site preparation, hand planting, chemical and mechanical vegetation control, and fertilization. Costs of items unique to tree improvement activities were approximated by totaling the estimated costs of materials and labor. In estimating labor costs, the man-hour requirements for workers in different wage classes were considered.

Based on DNR records some costs were known to increase at rates above the general inflation rate and the 1982 values were adjusted accordingly. Estimates of rates of cost increases above the average inflation rate ranged from 2.6 percent for labor to 8.7 percent for greenhouse operations (primarily heating). Examples of these estimates are found in Table 2.

Benefit Values. Benefits were defined as the value of increased stumpage produced as a result of using seedlings grown from seed produced by a program component. Determination of these benefits required: (1) estimating the acreage of plantations established with improved seed for each year of the project; (2) determining the increase in yield from this acreage due to the use of improved seed; and (3) establishing the discounted value of this increased yield.

Acreage estimates were based on seed production projections developed for the 1981 plan (MN DNR 1981), DNR nursery records of plantable seedling produced per unit of seed, the average number of seedlings planted per acre by the DNR and the average percentage of DNR plantings rated as successful. With the exception of the success ratio for plantings, these data were species specific. Plantation survival data by species were not available and the 1982 average value for all species, 69 percent, was used in all analyses.

Yield increases on these acres were projected using the product of the average yield per acre in Minnesota plantations and the estimates of percent genetic gain to be achieved. Genetic gain was estimated for a program component using values from the literature and/or unpublished data. The estimates used in these analyses are found in Table 3. In those cases where volume increase was not the goal of selection, an equivalent increase in volume was approximated.

Table 3. Estimates of percent increase involume growth due to genetic gain by species and activities.

Improvement Activity	Species					
	red pine	jack pine	white pine	white spruce	black spruce	black walnut
Seed Source Control	1.0	3.0	---	3.0	3.0	---
Seed Prod. Areas	2.0		---	8.0	---	---
Orchards						
1st gen. grafted	---	---	20.0	8.0	---	7.0
1st gen. seedling	5.0	8.0	---	---	8.0	---
Adv. gen. O.P.	---	13.0	---	17.0	14.0	---
Adv. gen. C.P.	---	18.0	---	22.0	16.0	---

The value of the increased volume was computed using current Minnesota stumpage prices adjusted for a real increase of 2,1 percent per year. In the analyses, stumpage values were discounted from the date of harvest (years to seed production + 3 years + average plantation rotation age) to 1982 values.

RESULTS AND DISCUSSION

A summary of the benefit-cost ratios generated by these analyses is presented in Table 4. Other measurements of investment generated by the analyses, while used in program evaluation are not summarized because of space limitation. It is important to realize that the results presented are specific to the procedures proposed for the Minnesota DNR program and relate to a specific cost-return situation. They are not intended for general application.

Table 4. Benefit - cost ratios from cash flow analyses. [a]

Program Component	Species					
	red pine	jack pine	white pine	white spruce	black spruce	black walnut
Source Control	56.7	807.8	---	291.1	219.9	---
Seed Prod. Areas	11.3-11.8	---	---	34.7	---	---
Seed Orchards						
1st gen. grafted	---	---	14.0	8.7-10.8	---	17.65
1st gen. seedling	4.2-4.5	6.5	---	---	.41-1.2	---
2nd gen. (open-pollinated)	---	13.8-16.2	---	12.9	1.3-4.0	---
2nd gen. (control pollinated)	---	14.9-15.5	---	16.4-16.8	1.6-5.5	---

[a] Ranges under a component - species combination result from variations in techniques and levels of implementation.

Because of the tentative nature of the cost and return estimates, the investment measurements generated by the analyses were used with considerable caution. In the review of the program they were used as indicators of the order of magnitude of returns and not as specific values. In addition, the sequential nature of tree improvement activities, the levels of risk associated with the biology of particular species and the probability of operational problems were all factors which conditioned our use of investment measures, The highest rate of return in all species was associated with seed source control (Table 4). Even in red pine, where the estimated level of genetic gain obtained by controlling seed source was very low, the potential level of return was large. These favorable benefit-cost ratios reflect the low cost of initiating seed source control and the short delay in the "production of improved planting stock. Even if the estimates of costs and benefits were exceedingly optimistic, investment in this form of genetic improvement appears to be one of the most favorable investment alternatives available in Minnesota forestry programs. Immediate initiation of a system of seed source control for all species grown in the nurseries was a part of the 1981 version of the tree improvement plan and this aspect of improvement received even greater emphasis in the 1982 revision.

The investment measures for other component-species combinations and revised estimates of seed needs led to some modification in program priorities. A significant change was raising the priority levels of white pine and black walnut clonal seed orchards. To a large degree this increase in emphasis reflects the favorable levels of return indicated by the analyses (Table 4). In addition, the development of jack pine seed orchards was given a higher priority because of an increase in the projected need for seed, relatively favorable rates of return and the opportunity for rapid implementation. Given the number of acres of jack pine seed orchard required, the levels of return suggest that advanced generation projects should utilize populations produced from open-pollinated seed.

Emphasis on red pine improvement was reduced. The revised estimates of future seed need are lower than those used in the original plan and the projected returns from seed orchard development were only moderate (Table 4). In addition, the rates of return indicated by the analysis are based on the assumption that reasonably priced techniques for harvesting seed from orchards and seed production areas will be developed. The level of risk associated with an investment in red pine improvement is increased because of that assumption. Although the plan recommends a reduction in the level of investment, red pine will continue to be a first priority species receiving a substantial allocation from the DNR's tree improvement budget.

Comparison of nursery vs. containerized (greenhouse) planting stock for red pine seedling seed orchards indicated slightly low benefit-cost ratios for the containerized planting stock. The higher cost of producing stock apparently was not offset by reduction in time to field planting. However, differences in the ratios were less than 5 percent (roughly 4.4 vs. 4.2) and probably should not be considered real. There seems to be no real reason to avoid the containerized systems, if they provide advantages when implementing programs.

In terms of relative levels of spending, emphasis on white spruce will also be reduced. This is not a function of the projected economic returns, which are more than satisfactory (Table 4), or the projected levels of seed needs, which have been raised. Substantial acreage of first generation grafted white spruce orchard was established over the past five years and opportunities for investment in the near future are limited, Second generation seed orchards will be based on populations produced using controlled pollination and this work will not be initiated until the results of progeny tests are available. While the development of seed production areas to help meet the large demand for seed is attractive, plans required that initiation of that activity be delayed until plantations derived from clonal orchard seed can be used,

The analysis of black spruce program components indicated relatively low rates of return from work with that species. Analyses of the first generation seedling seed orchard component using various assumptions indicated benefit-cost ratios from less than .41 to 1.2. Advanced generation components for black spruce appeared to provide acceptable returns in all cases. Under the most favorable assumptions, the benefits exceeded costs by a factor of approximately 5 with internal rates of return exceeding 20 percent. However, the measures of investment return are generally lower than those estimated for comparable activities with other species (Table 4) and the review led to a substantial reduction in the relative level of tree improvement resources allocated to black spruce. Future work will be concentrated on second generation orchard development following controlled pollination.

The black spruce analyses illustrate the critical relationship between non-genetic factors and the economic returns from tree improvement programs. An examination of the initial black spruce results suggested that the low rates of return were related to the 90 year rotation assumed for black spruce plantations and the low yield of plantable seedling per unit of seed (1 seedling/10 seeds). The rotation age was consistent with the use of black spruce seedlings on lowland sites. However, the yield of plantable seedling was well below the 35 percent usually reported (USDA Forest Service, 1974). When economic analyses were completed assuming plantable seedling yields of 30 percent, the internal rate of return for first generation seedling orchards reached 6.05 percent, a significant increase over the-6.5 percent found in the first analysis. The results illustrate the significant role of seed and seedling production levels and are consistent with Porterfield's (1977) statement: "profitability in a tree improvement program is directly and proportionately influenced by seed yield."

Results of the analyses also provided some insight into the effect of scale on economic returns. In general, increasing the acreages of seedling seed orchard components slightly increased the returns from investment. In the jack pine and black spruce analyses the internal rates of return increased by about 10 percent when the acreage of seedling seed orchard was doubled. No real impact of scale on return was noted in the red pine analyses. In contrast, increasing the amount of white spruce first generation grafted seed orchards from 20 to 40 acres reduced the benefit-cost ratio from 10.8 to 8.7. The analyses for these two levels of implementation are not strictly comparable because of differences in periods of seed production considered and the actual difference in economic value is probably small or nonexistent. The internal rates of return for the two levels of the project were essentially the same. In revising the plan, the effects of scale on returns played a minor role. Factors such as the projected needs for seed and the size of differences in levels of return among classes of program components dominated the decision making process.

Cash flow analysis, despite limitations in the data used, questionable validity of some underlying assumptions, and the restricted number of components evaluated, was a useful tool in the revision of the Minnesota DNR Tree

Improvement Plan. The analyses drew attention to general trends and aspects of the tree improvement program impacting economic return which might have been overlooked. They were of considerable aid in the establishment of priorities for program components and provided a basis for choosing between alternative approaches. In addition, the results have been invaluable in highlighting the investment opportunities offered by tree improvement.

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