Economic Aspects of Reforestation Planning on Woodland Properties

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There is no universal best way to carry out a reforestation program. Different owners have different objectives and different levels of available resources, as well as different on-the-ground conditions. The best reforestation program for one owner often will be different from that for another owner. There are some common considerations, however, that go into all reforestation planning efforts.

Criteria for Evaluating Reforestation Alternatives

The direct benefit of reforestation alone is very limited. The financial benefits come only from the total package of reforestation, management, and harvest. The amount of return to reforestation depends partly on the effectiveness of stand management and harvesting. To cite an extreme example, if there is no fire protection and the regenerated stand burns, there is no return to the reforestation dollars spent. On the other hand, an overstocked stand may be a partial reforestation "failure" in the sense that additional expenditures may be needed to reduce stocking to a desirable level. In the first case, the reforestation effort represents a total loss; in the latter case, extra costs reduce net returns, which could mean the difference between a profit and loss.

For this reason, the choice of a criterion by which alternative ways of reforesting a site are evaluated is crucial. The cheapest way to plant an acre may be the most expensive possible way if it results in all the seedlings dying, so that the planting must be repeated. Minimizing cost per *surviving* seedling is a better criterion, since it penalizes practices resulting in poor seedling survival. For an owner wanting only to establish tree cover to some minimum specifications on a site, the set of practices that result in the lowest cost per surviving seedling will accomplish the objective at the lowest possible cost. However, other owners may want to do more than simply establish a forest cover—they want to conduct a total program of reforestation, stand management, and timber harvesting as profitably as possible. For these owners, the minimum cost per surviving seedling criterion has shortcomings, as shown in the following example com-

paring this criterion with the recommended criterion—net present value.

Comparison of two criteria

As in all regeneration decisions, alternative practices or combinations of practices are available. In the hypothetical example summarized in Table 1, only two alternatives are considered to simplify the analysis. The first alternative is the combination of two practices: planting large stock and control of competing vegetation. The second alternative consists of planting normal, small stock and forgoing competition control. The planting density is the same for both alternatives—400 seedlings per acre. There are two primary benefits associated with the first alternative— higher survival (350 vs. 300 trees per acre) and a shorter rotation (48 vs. 50 years after planting). The advantage of the second alternative is its lower regeneration cost of $80 per acre as opposed to $130 per acre for the first alternative. At harvest, both alternatives result in a return of $11,000 per acre.

As shown in Table 1, Alternative 2 has a lower cost per surviving seedling, and would be selected if this criterion were used. Net present value per acre is a better criterion, however, since it includes consideration of all costs and revenues and their timing. Since net present value is highest for Alternative 1, large stock and competition control should be selected.

What is the meaning of net present value? It is the present equivalent in value of a contract, above and beyond the cost of obtaining the contract, for receipt of a specified amount at a specified future time. In the case of Alternative 1, the net present value, $927.56, is the present equivalent of an ironclad contract for receipt of $11,000, 48 years hence, for a current investment of $130, and assuming the interest rate is 5 percent. It is equivalent in the following sense: $927.56 plus $130 (the regeneration cost) invested at a 5 percent interest rate and compounded annually for 48 years would grow to $11,000. Stated another way, the opportunity to make a $130 investment now which promises to pay $11,000 after 48 years is worth $927.56, if the interest rate at which money can be borrowed and invested is 5 percent.

The point of the example is not that large stock and competition control should be used—different costs, survival rates, interest rates, or harvest values could change this. The point is that if optimum reforestation decisions are to be made, costs must be compared with final *outputs* of the reforestation-management-harvest program rather than with inputs, such as seedlings, acres, or even established seedlings.

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Table 1. Comparison of cost per established seedling and net present value as criteria for selecting among reforestation alternatives. Hypothetical data used.

Situation	Alternative 1: large stock and competition control	Alternative 2: normal stock; no competition control
Planted seedling/acre	400	400
Surviving trees/acre expected	350	300
Total expected reforestation cost, dollars/acre	130	80
Years from planting to harvest	48	50
Harvest value, dollars/acre	11,000	11,000
Criteria		
Cost/surviving seedling in dollars	0.37	0.27
Net present value of harvest returns[1] in dollars/acre	927.56	879.24

Calculations

Cost per surviving seedling

$$\frac{130}{350} = 0.37 \qquad \frac{80}{300} = 0.27$$

Net present value[1] of harvest dollars/acre
Large stock and control:

$$\frac{11,000}{(1.05)^{48}} - 130 = \frac{11,000}{10.40} - 130.00$$
$$= 1,057.56 - 130.00$$
$$= \$927.56$$

Normal stock: no control:

$$\frac{11,000}{(1.05)^{50}} - 80 = \frac{11,000}{11.41} - 80$$
$$= 959.24 - 80.00$$
$$= \$879.24$$

[1] Net present value is defined as the present value of returns minus the present value of costs. Costs, incurred now, are already in present value terms, but harvest returns (since they occur in the future) are calculated using the standard discounting formula:

$$V_o = \frac{V_n}{(1+i)^n}$$

where V_o = present value at year o
V_n = future value at year n
i = interest (discount rate) expressed as a decimal

Accounting for inflation

If you plan to make a net present value calculation, remember inflation or deflation. The prices used in calculating future returns and the interest rate used are very important. In considering prices

and interest rates, it is important to account for anticipated inflation properly. Price increases over the future may come from two sources: (1) as a result of increases in the value of wood *relative to other goods and services* in the economy, and (2) as a result of general inflation in the price level of all goods and services. Similarly, an interest rate to be earned in an investment can be viewed as the sum of two components: (1) the rate of increase in purchasing power of the investment cost, and (2) the rate of general price inflation. In making a present value analysis, the prices and interest rate used should be consistent in either including or excluding general inflationary effects in both. If the prices used are anticipated future dollar prices including inflationary increases, the interest rate should also include inflationary effects. On the other hand, if price forecasts used are in terms of constant dollars as of a particular base year, the interest rate used should not include the general inflation effect. An example of this follows:

Suppose that over the next 50 years, an average annual general inflation rate of 5 percent is expected, and money is expected to be available at a 12 percent interest rate. In addition, the real stumpage prices (i.e., net of inflation) in terms of today's dollars are expected to increase above today's $60/cunit[1] at an average annual rate of 2 percent. In 50 years, this will result in a real price (in present dollars) of 60 x $(1.02)^{50}$ = $161.50 per cunit, and the price in the inflated dollars of 50 years from now will be $1851.93 per cunit.[2] In a present value analysis, the inflated future price ($1,851.93) may be discounted using the inflated interest rate (12 percent), or the deflated future price ($161.50) may be discounted by the deflated interest rate (6⅔ percent).[3] But the inflated price should *not* be discounted with the deflated interest rate. Note, also, that the issue

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[1] A cunit is one hundred cubic feet.

[2] The relationship between the real rate of return (r), the inflation rate (h), and the overall rate of return including inflation and real return (f) is:
$$1 + f = (1 + h)(1 + r)$$
where f, h, and r are expressed as decimals. In this example (1.05) x (1.02) = 1.071 and 60 x $(1.071)^{50}$ = $1851.93.

[3] The deflated interest rate is calculated by rearranging the formula presented in the previous footnote. That is, if the inflated interest rate is f, the rate of general inflation is h, and the deflated interest rate is r, then
$$(1 + r) = (1 + f)/(1 + h),$$
or for our example
$$(1 + r) = 1.12/1.05 = 1.0667, \text{ and } r = .067$$
To see that the same present value can be calculated by consistently using either inflated or deflated values, check the following:
$$\text{Inflated values: } \$1,851.93/(1.12)^{50} = \$6.41$$
$$\text{Deflated values: } \$161.50/(1.0667)^{50} = \$6.41$$

of future price may not be dodged by simply using today's prices, because this amounts to making an implicit assumption of no real price change.

Using a Decision Tree in Analysis of Reforestation-Management Alternatives

The interdependence among reforestation decisions and among reforestation and management decisions has been mentioned. In order to emphasize this interdependence and to illustrate how the economic (financial) impact of one alternative set of decisions might be estimated, a hypothetical example is presented.

Figure 1, page 8, shows one possible path (solid line) through a "decision tree." Each branching point represents a decision. Lower branches are reforestation decisions; upper branches represent stand management, harvest, and marketing decisions. Only one complete path through the tree is shown. The number of possible paths might number in the thousands in a detailed analysis.

The solid line path shown represents one combination of decisions or management prescriptions to be evaluated, namely:

Broadcast burn a recent clearcut;

Plant 600 2-0 bare-root (B-30-6-2.5)[1] Douglas-fir seedlings per acre;

No chemical brush control spray;

No replanting of "holes" after initial planting;

Stocking control and fertilization at 20 years;

Thinning regime "A" (commercial thinnings at years 40 and 50);

Clearcut at 60 years; and

Sell sawtimber logs only.

Computer technology enables evaluation of all alternative paths, but even without computers one can select the most likely paths (sets of decisions) for a given site. Each path is evaluated to estimate which is financially superior and by how much.

The sequence of decisions shown in the "decision tree" (Figure 1) is not necessarily the sequence in which the decisions are made; it is the sequence in which they are implemented. For example, if non-standard seedlings are to be planted in year zero, usually the seedlings will have to be ordered at least two years before year zero to ensure that stock with the specified characteristics will be ready.

The calculation of financial impact associated with this set of

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[1] New seedling nomenclature representing bare-root seedlings that are 30 cm. tall, 6 mm. in diameter and with a shoot to root ratio of 2.5.
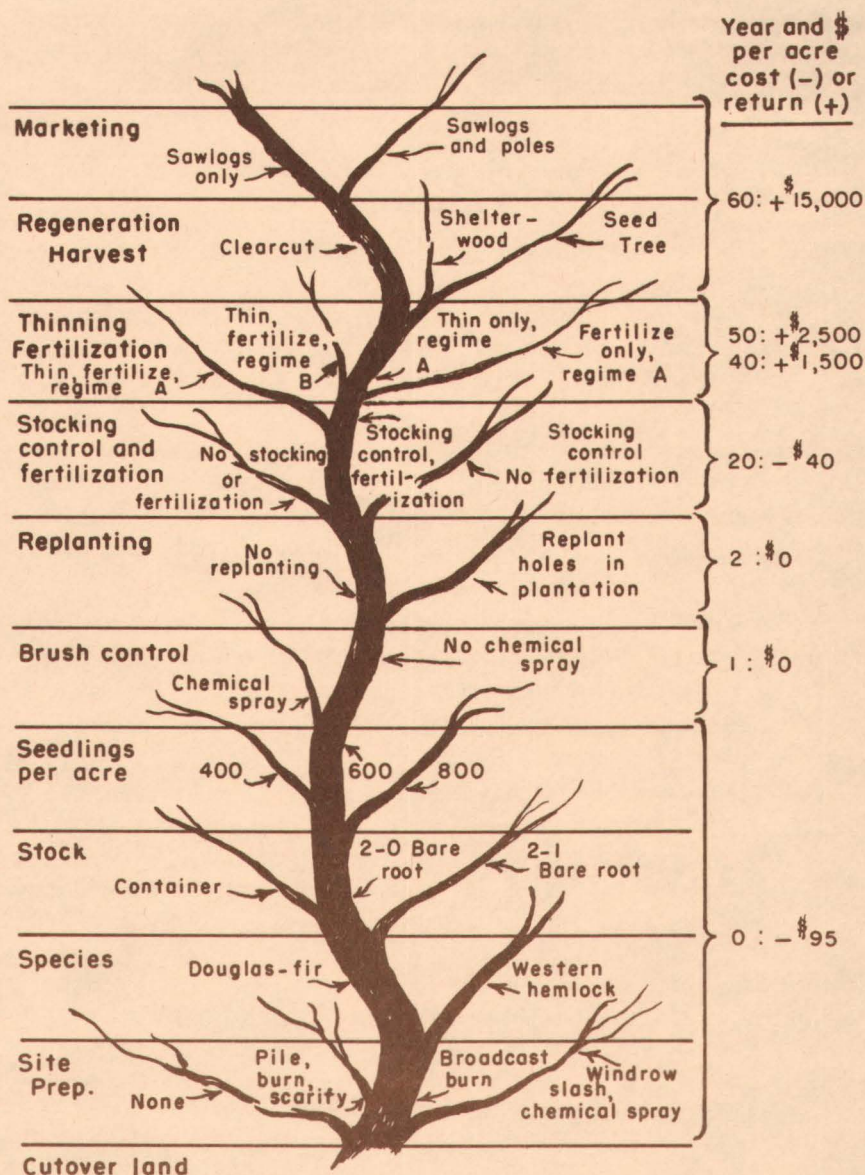
Figure 1. Decision Tree.

decisions is summarized in Table 2. Each estimate of cost or revenue is discounted to year zero. This is done by dividing each deflated cost or revenue by the discount factor, $(1 + i)^n$, where i is the deflated interest rate expressed as a decimal and n is the number of years from the present until cost or revenue will occur. A 5 percent (.05) discount rate has been used in this example. Discount factors

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Table 2. Calculation for Net Present Value[1] Associated with the Set of Establishment-Management-Harvest Decisions Represented in Figure 1.

Operation(s)	Years from present (n)	Per acre cost (−) or revenue (+)	Discount factor $(1.05)^n$	Present value of cost or revenue
Harvest	60	+ $15,000	18.68	+ $803.03
Thinning 2	50	+ 2,500	11.47	+ 218.01
Thinning 1	40	+ 1,500	7.04	+ 213.07
Stocking control, fertilization	20	− 40	2.65	− 15.08
Regeneration	0	− 95	1.00	− 95.00
Net present value[1]				+ $1,124.03

[1] The term net present value should not be taken literally here, as many costs, including taxes and protection costs, are ignored to simplify the example.

may be looked up in compound interest tables, or calculated on many electronic calculators.

In this hypothetical example, the financial impact of the set of decisions analyzed is a positive $1,124.03 per acre. This value should be compared with other values corresponding to alternative paths up the decision tree.

Economic Considerations of Different Reforestation Decisions

In planning reforestation programs, different types of decisions must be made. Some of these decisions are listed here, along with a general discussion of some economic considerations pertaining to each. In most situations, these may be considered as things to think about; in large or complex operations they may be things to subject to formal economic analysis. As such, each would be a branching point in a decision tree.

Artificial vs. natural regeneration

Natural regeneration has one primary advantage over artificial regeneration—little or no initial dollar outlay is required. In some instances, natural regeneration may be the only practical alternative. Some small-forest owners, for example, cannot afford *any* cash outlay. The considerations are more complex in the overwhelming majority of circumstances.

Generally speaking, natural regeneration of even-aged stands involves delays—either in harvest of the next crop or in harvest of some of the present crop. In either case, the delay in income is costly.

Much is said about the opportunity to increase forest production through improved genetic stock. Faster growth rates, improved disease resistance, and other attributes with dollar benefits are

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potentially available. A commitment to natural regeneration is a commitment to forego the benefits of planting genetically improved stock. To date this has not been an important factor, since proved, genetically improved stock has not been available readily to most owners, but it may be an important consideration in the future.

Natural regeneration may result in significantly higher logging costs if species requirements dictate single-tree or group-selection silvicultural systems, or other systems with small acreages or volumes removed in any single entry.

Site preparation

Site preparation is closely related to harvesting methods. It is often cheaper to achieve some site-preparation goals, such as scarification and slash disposal, during the harvesting operation rather than after harvesting. Nonetheless, there are always some site preparation considerations that must be faced.

Slash disposal is an important part of site preparation. Obvious considerations include dollar outlays required for different forms of slash disposal, and fire, insect, and disease hazard remaining after slash disposal. There are less obvious considerations of economic importance. Slash piling and windrowing can involve withdrawal of land from production in cases of high slash volume. Burning large piles or windrows can reduce the productivity of the underlying land if fires are very hot.

Scarification may have long-term costs in terms of reduced site productivity. For example, if topsoil removal and soil compaction reduces the site index of the land, future yields and incomes will be reduced.

Planting stock

Selection of species and stock size, and selection between containerized and bare-root stock, involve looking beyond stand establishment. Not only are stock and planting costs important, growth rates should be considered too, since they determine the amount of eventual product to be sold and the time when that product will be available. Average survival determines the average number of seedlings needed to realize a given stand stocking level. Different sizes and types of stock have different survival potentials under various field conditions. Therefore, survival potential is an important consideration in stock selection. Consider also whether planting larger stock will shorten the time until harvest, or result in more uniform survival so that original planting density and subsequent stocking control costs can be reduced. Thus, planting stock selection depends on much more than just stock cost. This was illustrated in Table 1.

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Planting density

One hundred percent survival is unlikely to be attained. It is common to compensate for mortality by planting more than the desired number of trees per acre. How much compensation is desirable—10 percent extra—100 percent extra? Higher planting densities reduce the number of occurrences of replanting, and replanting is extremely costly. High planting densities, however, result in more overstocked plantations. In turn, overstocking has economic costs either in the form of reduced merchantable yields and values, or costs of undertaking stocking control. The tradeoff is between higher stocking control costs on one hand, and either high costs caused by more replanting costs, or lower yields resulting from more understocked stands on the other.

The planting density decision should be linked to future stand management plans. If stocking control is not planned, high-stand densities should be avoided. Stand density ultimately affects the size and form (and therefore, value) of logs removed. Small logs contain less merchantable volume and the value per unit volume is lower. On the other hand, if stocking control is planned, initial overstocking may not be significant. In fact, there may be advantages to higher stocking levels if the thinning can be conducted so that remaining trees have increased average growth capacity.

Replanting criteria

No matter what is planted, how it is planted, when it is planted, or if natural regeneration is chosen rather than planting, there will be some understocked areas. This requires certain replanting decisions. If replanting is needed, what type of stock should be used? How densely should it be planted? Nearly all questions faced in the original reforestation effort rise again.

Other questions also are pertinent. Under what circumstances is replanting appropriate—what is the maximum size "hole" in the stand that will be tolerated? If the discounted value of reduced yields because of holes is less than replanting costs, replanting in holes is not financially justified. What is the minimum stocking below which it is more profitable to start over with a new plantation rather than merely trying to fill in holes? Under what conditions should a massive failure simply be written off? From a financial point of view, the fact that past costs have been incurred should not affect present decisions. Some sites have been planted and replanted at a cost measured in hundreds of dollars per acre. The temptation is to give the site a high priority for replanting because so much money has already been invested in it. Yet such sites often should be given lowest priority. They frequently are inherently the most

difficult sites to reforest and usually have been made even more difficult by establishment of a heavy brush cover during the time since harvest. These conditions result in high costs, and consequent lower net present values.

Under the Oregon Forest Practices Act, reforestation of clear-cuts is mandatory unless land use is changed from forestry to some other enterprise. Thus, most industrial concerns and agencies will keep attempting to reforest difficult sites. A farmer owning wood-lands with such a site may consider investigating conversion to pasture or other land uses for these sites (although conversion to pasture also can be costly).

Record-Keeping and Information Needs for Reforestation Planning

Needless to say, owners who have continuing year-to-year reforestation programs should have ongoing programs of monitoring stock costs, planting costs, site preparation costs, survival rates, re-planting costs, and labor productivity. This information is needed in reforestation planning, and the figures change with changing economic conditions and reforestation practices. Only with such data can reforestation planning and execution become more sophisticated than an educated guess.

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