Chapter 2
Reforestation Economics, Law, and Taxation

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Abstract

Regeneration decisions depend on the landowner's management objectives, the biologically possible harvest and regeneration alternatives acceptable for the site, and the economic costs and returns for the investment. This chapter describes how economics, law, and taxation affect regeneration decisions. The first step in an economic analysis is determining the biologically and legally feasible management practices and their timing; the next step determining the costs of inputs to grow trees and the prices to be received at harvest. Cash-flow schedules for each management alternative must then be developed and those cash-flows discounted to determine present values and rates of return. Various criteria for financial investment decisions should be compared and tax consequences considered. Lastly, summaries of economic evaluations and recommendations are presented to decisionmakers.

2.1 Southern Pine Regeneration Economics

More than sound basic biological knowledge is needed to ensure good pine regeneration. Sound application of economic principles is crucial. In fact, regeneration decisions are usually dictated more by economic than biological criteria. Private and public forest landowners alike have limited capital to invest in timber production or other assets. As such, they try to choose the regeneration alternative that will minimize costs, maximize returns, or meet some other specified objective. Forest products firms generally try to maximize the value of their company, i.e. their stock price plus dividends, for their shareholders. To do this, they invest in whatever assets will yield the greatest returns, whether they be plants, modernized equipment, timber stand improvement, or regeneration. Otherwise, stock prices, dividends, and capital budgets will suffer.

Nonindustrial private forest (NIPF) landowners' decisions also depend largely on regeneration costs and potential returns. Few rural or urban residents who own forestland want to spend excessive amounts of capital on regenerating a forest stand. Even though a reasonably well-stocked stand may have aesthetic value for these owners, which may affect their choice of harvest type and regeneration method, they too must focus on return on investment.

Public landowners are no more likely than private landowners to invest in regeneration for strictly biological reasons. Public agencies, including the U.S.D.A. Forest Service and the individual states, have limited annual operating budgets. All public sectors have reported significant backlogs of land needing reforestation. Thus, they must decide which areas need to be regenerated most, budget the regeneration costs, and select alternatives that will maximize use of the area regenerated, the return on investment, or both.

In short, all regeneration decisions depend on the landowner's management objectives, the biologically possible harvest and regeneration alternatives acceptable for the site, and the economic costs and returns for the investment. In this chapter, we focus on the economic considerations, which often determine regeneration decisions. To present the fundamental economic concepts, we use basic biological management regimes and regeneration alternatives that are common for southern pine. These are meant to illustrate economic applications, not provide definitive estimates of costs and returns for all practices. Note that measurements are given in both English and metric units (the U.S. literature cited in this chapter always used English units). English to metric conversions for land areas were made with multipliers published by Miyata et al. [27]; timber volume conversions were computed by the chapter authors. Some discussions remain in English units, because they refer to public programs and laws that specify common U.S. measurements. With the economic principles presented in this chapter, owners' objectives, detailed biological knowledge summarized in the following chapters, and site-specific data, landowners and resource managers can calculate actual costs and returns for various regeneration strategies.

2.2 Production Economics

Production economics and forest finance are the

M.L. Duryea & P.M. Dougherty (eds), Forest Regeneration Manual, pp. 9–31.

principal foundations needed for analyzing forest management, harvest, and regeneration options. After the owner's objectives are ascertained, basic production functions for biological relationships must be determined, costs of inputs used to regenerate forest stands projected, and possible management regimes and resultant product prices estimated (Fig. 2.1). Regeneration decisions must consider the entire rotation of a forest stand. Once the quantity and timing of inputs and outputs are determined, management and regeneration alternatives may be selected on the basis of financial criteria such as net present value or internal rate of return. Economic analyses should be performed on a before- and an after-tax basis and possible changes in public policies considered.

2.2.1 Production Functions

All economic analyses of forest management and regeneration decisions rest on the underlying biological production functions. Production functions are the basic input-output relationships that relate the amount of material used to the amount of product made. In the case of southern pine regeneration, the inputs affecting stand yield (and discussed in subsequent chapters of this volume) include harvest method, seed source, planting stock, planting density, soil and site factors, competition control, and desired product mix. The biological and physical effects of each of these factors, performed at various times during a stand's establishment, growth, and harvest, must be specified for economic analyses (Fig. 2.1, step 2).

In practice, many biological relationships may not be well known. Nevertheless, management decisions about optimal regeneration methods must and will be made. Therefore, the analyst must rely on the best available data to estimate the relationships between regeneration alternatives and subsequent stand yields. This may involve the use of approximate estimates of the increases in site index from planting genetically superior stock or controlling competition (see 2.5.3), empirical estimates of yield differences based on growth and yield research, or even "best guesses" regarding the probable percentage increase or decrease in yields based on various regeneration factors employed, such as competition control, fertilization, or genetically improved seedlings.

Production functions may be determined as mathematical equations, average values for the entire treatment, or tabular relationships. Growth and yield responses to many southern pine management treatments are often available in mathematical form. Estimates of the number of seedlings planted and their genetic quality, mechanical or chemical site treatments, and labor required are more apt to be averages. Tabular production functions could include growth and yield tables, schedules of planting productivity per person or machine, or tables relating area treated to time required.

In forest regeneration, productivity, costs, and returns for many treatments vary depending on tract size, number of seedlings or trees, volume, or other factors. Almost all forest operations have some fixed setup time and costs. Fixed time for planting and timber stand improvement will raise average costs on small tracts. Average harvesting costs also tend to be greater for small tracts or for small volumes, which will tend to reduce stumpage prices. If possible, functional relationships that capture these differences in average productivity and costs or stumpage prices should be used. Cubbage and Harris [1 1] summarize much of the current literature regarding these tract size, volume, and price relationships.

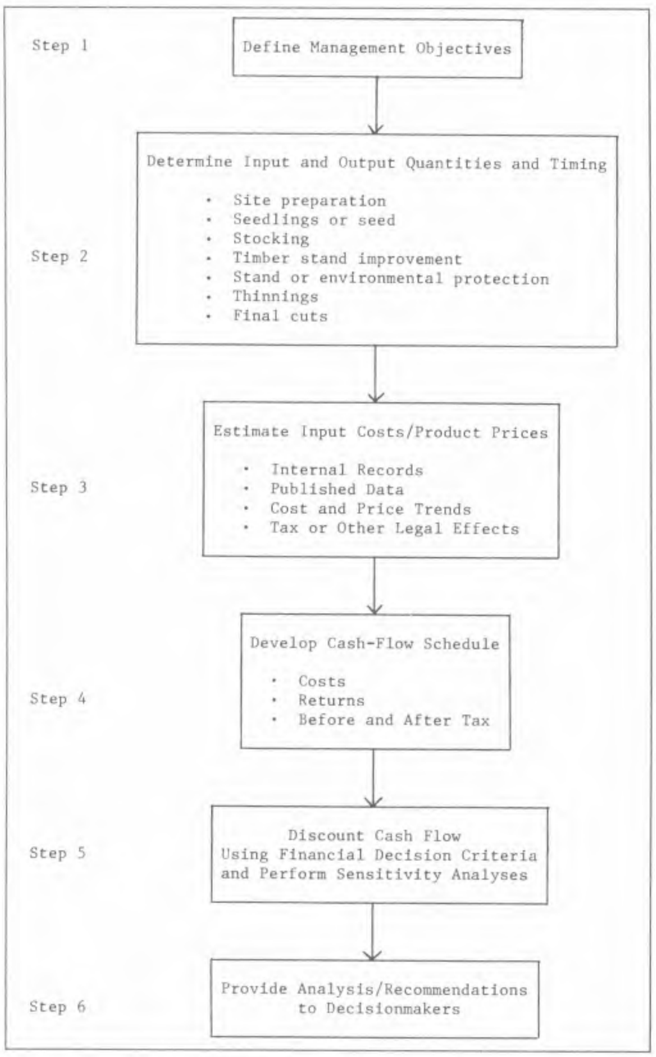

Figure 2.1. Steps in financial analysis of forest regeneration and management alternatives.

2.2.2 Physical Flow Table

Once the management objectives and biologically feasible regeneration alternatives have been determined, a table summarizing the physical flows of inputs and outputs per unit area — by year and type of activity — should be established for each management regime. The first year in the physical flow table (year 0) would include all the initial activities performed to establish a new stand, such as site preparation and planting. For even-aged management such

Table 2.1. Physical flows for loblolly pine seedtree management regime, site index 65, at base age 25. (See Table 2.4 for cash flows.)

Activity	Year 0	4	11	18	21	25	30	32	40	44
	Input or output/ac. (ha)									
Input or cost										
Prescribed burn (gal./L)	x								x	
Labor (days)	0.025(0.062)									
Equipment (hours)	0.100(0.247)									
Fuel (gal./L)	0.500(4.69)									
Scarify site	x								x	
Labor (days)	0.025(0.062)									
Equipment (hours)	0.300(0.741)									
Apply herbicides	x								x	
Labor (days)	0.025(0.062)									
Equipment (hours)	0.020(0.049)									
Chemicals (gal./L)	0.020(0.185)									
Prescribed burn			x	x		x		x		
Labor (days)			0.040(0.099)	0.040(0.099)		0.040(0.099)		0.040(0.099)		
Equipment (hours)			0.020(0.049)	0.020(0.049)		0.020(0.049)		0.020(0.049)		
Fuel (gal./L)			0.500(1.89)	0.500(1.89)		0.500(1.89)		0.500(1.89)		
Property taxes	x	x	x	x	x	x	x	x	x	x
Management charges	x	x	x	x	x	x	x	x	x	x
Timber marking/sale		x			x		x		x	x
Income taxes		x			x		x		x	x
Output or return										
Commercial thinning					x		x			
Pulpwood (ft^3 or m^3)					704(49.2)		640(44.8)			
Chip and saw (ft^3 or m^3)							274(19.2)			
Sawtimber (ft^3 or m^3)										
Final harvest	x									
Pulpwood (ft^3 or m^3)										0
Chip and saw (ft^3 or m^3)										648(45.3)
Sawtimber (ft^3 or m^3)										560(39.2)
Harvest seedtrees (ft^3 or m^3)										2593(181.3)
Hunting leases	x	x	x	x	x	x	x	x	x	x

Note: an "x" indicates that an activity occurs in that year, but the time or cost varies by operation.

as seedtree or shelterwood methods, site preparation techniques such as prescribed burning or scarification would constitute the initial stand treatment in year 0. For uneven-aged management, determining the initial year for the physical and financial analysis is difficult. Generally, the analyst must assume that a similar series of management activities repeats throughout the life of the stand, and then choose one of the harvest/regeneration points as year 0.

Table 2.1 depicts an example of physical flows for a typical seedtree management regime for loblolly pine (Pinus taeda L.), site index 65 (height of 65 ft, or 19.8 m, at base age 25 years). Management inputs could include some site scarification and prescribed burning at the time of harvest, herbicide application to control large hardwoods, and periodic prescribed burns to control hardwood vegetation during the life of the stand. If sawtimber were the desired output (final product), there would probably also be intermediate commercial thinnings for pulpwood and chip-and-saw material. The seedtrees left after final harvest would be cut about 4 years later, once the new stand had been established. If artificial regeneration had been used rather than planned natural regeneration, then the table would also include the costs of seedlings and of the planting operation itself. The inputs are general averages. However, because individual tracts may differ in terms of size, terrain, or existing herbaceous cover, it is often preferable to analyze each tract separately to account for the resulting differences in treatment time and costs. Costs such as property taxes, annual management expenses and charges for timber marking and sale administration, and income taxes may vary depending on the harvest (management) and regeneration regimes adopted. A landowner may also borrow money to pay for regeneration, which would be income in the year in which funds were borrowed. Loans would have to be repaid, probably before commercial timber was cut; this would be a cost in subsequent years. Land acquisition could be considered a cost (and sale a return), but for most regeneration analyses, cost of land is a "sunk" cost — an expense already paid for and not relevant in the (regeneration) decision. Thus it is easier to exclude it from the economic analysis, although not all economists agree with this approach.

Returns from regeneration investments might consist of intermediate and final harvests, cash loans for stand establishment (or purchase), and perhaps returns from hunting leases or other benefits. Again, all of these will vary depending on the management regime adopted, as well as other factors. Income tax benefits can be derived from regeneration expenses. Most notably, the reforestation tax incentives law provides an income tax credit in the initial year and deductions in subsequent years for planting trees (see 2.3.2.2).

2.2.3 Costs and Prices

Once the physical flows from the various regeneration and management regimes have been determined, the cost of those inputs and prices for those outputs (products) must be estimated (Fig. 2.1, step 3).

2.2.3.1 Input costs

If the number of hours of machine time or labor and the quantity of other inputs are known, they can be multiplied by their per-unit cost to determine total cost for each input. This is probably the best way to estimate costs because it allows the analyst to periodically update a physical flow table.

For many cost analyses, however, average costs for each type of activity are sufficient. For example, prescribed burning may cost an average of $3.25/ac. ($8.03/ha), site preparation (burn, chop, and bed) $90/ac. ($222/ha), and killing undesirable hardwoods $40/ac. ($99/ha). Average costs provide less detailed information than do input quantities times input costs, but are usually adequate for comparative analyses among different management regimes.

Data on costs may be gained from several sources. If the production function approach is used, direct estimates of labor, machine, fuel, and chemical costs may be obtained from retail sales outlets or company records. Average costs for individual treatments could be obtained from past experience of a firm or public agency; these could be based on the organization's internal costs to perform the work, or on the rates charged by contractors. Consulting forestry firms should also have such cost data readily available in their records.

If internal data are unavailable, costs of southern forest management practices have been surveyed and reported periodically by researchers at Mississippi State University. These are published biennially in the *Forest Farmer Manual*, [e.g. 39]. Average (1986) costs for selected regeneration and management activities in the South are listed in Table 2.2. However, these average costs can mask regional differences, which should be taken into account in economic analyses. Watson et al. [39] also provide percentage breakdowns of the costs by labor, equipment, supervision, and other overhead factors.

Table 2.2. Selected average southern pine regeneration and management costs, 1986 (adapted from Watson et al. [39]).

	Average cost		
Management activity	$/seedling	$/ac.	$/ha.
Site preparation			
Shear, rake, and pile		125.81	310.88
Shear, rake, pile, and bed		173.94	429.81
Shear only		57.20	141.34
Bed only		24.97	61.70
Single chop		52.96	130.86
Double chop		83.79	207.05
Chop and bed		84.23	208.13
Shear and bed		125.29	309.59
Disk only		60.22	148.80
Planting			
Machine, old fields	0.033	26.79	66.20
Hand plant, intensive site preparation	0.051	33.44	82.63
Hand plant, moderate site preparation	0.055	38.78	95.83
Machine plant, intensive site preparation	0.045	30.35	74.99
Machine plant, moderate site preparation	0.046	29.20	72.15
Burning			
Prescribed, drip torch		3.29	8.13
Prescribed, aerial		4.10	10.13
After chemical site preparation, drip torch		7.15	17.67
After chemical site preparation, aerial		7.39	18.26
Chopped areas, ground		7.95	19.64
Chopped areas, aerial		6.20	15.32
Slash piles, ground		5.86	14.48
Chemical treatments			
Aerial spray		77.29	190.98
Backpack		64.07	158.32
Injection		41.11	101.58
Spot gun		58.34	144.16
Other			
Fertilization		36.03	89.03
Fire protection		0.79	1.95
Timber cruising (10%)		3.27	8.08
Timber marking			
regeneration cuts		17.00	42.01
thin plantations		10.64	26.29
thin natural stands		6.70	16.56
Precommercial thinning		52.44	129.58

2.2.3.2 Product prices

Price estimates for products also influence regeneration decisions. In areas that have active sawtimber markets and good prices, it may be best to use long rotations and wide spacings to produce large-diameter trees. In areas that have high pulpwood prices, such as the southeastern Coastal Plain, short rotations and close spacings may be best to maximize volume production. In practice, most owners hedge their bets regarding product prices by planting enough trees to grow either sawtimber or pulpwood.

As with costs, product prices may be estimated either from company records or published literature. Forest products firms that buy stumpage should have historical data on timber prices. Consulting firms that assist landowners may maintain records of their sales. Public agencies such as the Forest Service and a few states also compile data on timber prices.

Data on southern pine timber prices have been published monthly by Timber Mart-South (1977-87) [35] and in the biennial *Forest Farmer Manual* (e.g., Table 2.3, Neal and Norris [29]). National Forest stumpage sale price data have also been published in the past [17], and still may be requested from the Forest Service Regional Office in Atlanta. Louisiana has reported stumpage prices since at

Table 2.3. Average southern pine stumpage prices, 1985 (adapted from Neal and Norris [29]). [1]

State	Sawtimber		Pulpwood		Chip and saw	
	$/MBF Scribner	$/M^3	$/cord	$/M^3	$/cord	$/M^3
Alabama	143	23.83	18.70	7.78	42.80	16.21
Arkansas	120	20.00	13.10	5.45	40.30	15.27
Florida	147	24.50	24.90	10.36	44.00	16.67
Georgia	150	25.00	21.40	8.90	44.90	17.01
Louisiana	122	20.33	14.90	6.20	39.80	15.08
Mississippi	126	21.00	13.40	5.57	40.20	15.23
North Carolina	132	22.00	9.90	4.12	27.30	10.34
South Carolina	149	24.83	16.40	6.82	42.50	16.10
Tennessee	76	12.67	8.70	3.62	–	–
Texas	116	19.33	16.00	6.66	36.10	13.67
Virginia	100	16.67	11.30	4.70	28.70	10.87
Average	120	20.00	14.30	5.95	38.90	14.73

[1] Sawtimber: 13+ in. (32+ cm) dbh; 1 MBF Scribner = 6.0 m^3.
Pulpwood: 4 to 7 in. (10 to 18 cm) dbh; 1 cord = 2.404 m^3.
Chip and saw: 8 to 12 in. (19 to 31 cm) dbh; 1 cord = 2.64 m^3

least 1955 [22]. The Louisiana and National Forest data are also published periodically in a Forest Service publication by Ulrich [36]. Stumpage prices in Georgia have been summarized recently by Cubbage and Davis [9] and are still updated annually.

All the stumpage price series provide useful averages for a particular region. Individual sales, however, will vary considerably because of tract location, accessibility, and size, volume removed per unit area, site index, topography, season, and number of bidders. Some of these factors can be considered in a regeneration decision. In particular, the larger volume per tree can decrease harvesting costs, which may influence stumpage price. Managers can influence volume per tree by controlling spacing and competition. Larger trees may also be worth more because they yield higher value end products than small trees.

2.2.3.3 Cost and price trends

Trends in input costs and product prices are crucial in financial analysis of forestry investments. Investment analyses can be performed with either nominal prices, which represent current dollars including inflation, or real prices, which represent constant dollars (current dollars excluding inflation). Nominal prices may increase or decrease from one year to another, but generally increase over time. Real prices may not. However, real dollars and rates are usually easier to work with and interpret than nominal because all unit values tend to stay at their initial levels (although, for tax purposes, at least under current law, a nominal dollar analysis is better because an owner is taxed in terms of nominal, not real, costs and returns). Additionally, inflating all costs and prices often generates large values that are difficult to comprehend. Thus most of our analyses of regeneration alternatives use real costs and prices. For comparisons among alternative management strategies, real analyses usually yield the same relative rankings as nominal and are simpler to apply.

Price changes may still be used even in analyses performed in real terms. The relevant question is whether real prices (without inflation) for a factor are increasing or decreasing. If the real prices have been constant, current base-year prices probably do not need to be adjusted. If the prices have increased at a rate more or less than inflation, some adjustment in future prices should be made.

Cost and price trends may be determined in three principal ways: (1) as a compound rate between two periods; (2) as a simple linear regression of prices as a function of year; or (3) as a compound (logarithmic) regression of prices as a function of year. First, they may be determined using the compound interest rate that would make the future value equal to the initial value:

$$V_n = V_0(1+i)^n \quad (1)$$

$$V_n/V_0 = (1+i) \quad (2)$$

$$(1+1) = (V_n/V_0)^{1/n} \quad (3)$$

$$i = (V_n/V_0)^{1/n} - 1 \quad (4)$$

where:

V_0 = value in year 0
V_n = value in year n
n = number of years in rotation
i = interest rate.

This method yields a compound interest rate for changes in value between two periods. But it must be used with caution because it is based only on two points in time, i.e., V_0 and V_n. Since yearly price and cost fluctuations vary considerably, if one chooses a year in which V_o were at a yearly peak and V_n at a yearly trough, then price-level trends would be deceptively low. Conversely, if V_0 were at a yearly trough and V_n at a yearly peak, price trends would be deceptively high. Thus, this approach should be reserved for measuring from one similar point in the business cycle to another.

Second, cost and price trends may be estimated with least-squares linear regression. This approach requires cost or price data for several years. Trends are estimated by regression price as a function of year:

$$\text{price} = a + b\,(\text{year}) \tag{5}$$

where:

a = intercept for the regression line

b = slope of the regression line.

The resulting coefficient for b gives the annual price increase in decimal form, e.g., 0.045. Multiplying by 100 yields the annual percentage increase in prices, e.g., 4.5%. This method is more statistically efficient than the simple interest approach because it uses all the price information for all years.

However, prices should increase in a compound, not linear, fashion. Third, then, cost and price trends may be estimated with regression, plus a log transformation of year to account for compound price increases:

$$\log(\text{price}) = a + b\,(\text{year}) \tag{6}$$

Taking the antilog of the coefficient for h and subtracting 1 gives the annual price trend in decimal form. Multiplying by 100 yields the annual percentage increase in price. This method is theoretically superior because each year's prices should be a function of the prior year's prices and the interest rate, which would be compounded over the duration of the analysis.

Historical data have suggested that prices for southern pine sawtimber have increased at rates from 1 to 3% more than inflation per year. Pulpwood prices have increased only at about the same rate as inflation [25, 37]. This means that an annual real sawtimber stumpage price increase of 1% and pulpwood increase of 0% would be reasonable — conservative figures on the average — although this may vary across the South.

The cost trends for forest management practices in the South seem to have varied more than the timber prices. Watson et al. [39] estimated indexes for prices from 1967 to 1986 and compared them to the producer price index. Prescribed burning costs seemed to increase at about the same rate as inflation, machine planting costs slightly less, and hand planting costs substantially less. Costs for chemically removing undesirable trees increased at almost twice the rate of inflation, those for mechanical site preparation and timber cruising about 30% more. Costs of marking trees for harvest increased only slightly more than inflation. These trends could be factored into analyses for different regeneration regimes. Because most of these costs occur at stand establishment, the analyst would often not need to inflate their values throughout the rotation.

2.2.3.4 Discount rate

Another crucial factor in forestry financial analyses is determining the appropriate discount rate. In principle, the discount rate represents the opportunity cost of using capital — the value of postponing consumption for 1 year instead of using capital in the current year. Most regeneration analysts are likely to have to use discount rates determined by corporate or agency policy.

Forest products firms usually use a corporate weighted average cost of capital as the discount rate [12]; this comprises debt (bonds, borrowing) and equity (stock) components. In 1984, the average before-tax nominal discount rate for forest products firms was 14.9%; real discount rates averaged about 10.9%. Although these rates have declined considerably since the more inflationary periods of the 1970s, they still are quite high and would tend to make most forestry investments unattractive. Forest products firms, or other publicly held corporations for that matter, have seldom generated such high annual rates of return for any extended period, so a lower real discount rate might not be unrealistic. Ibbotson and Sinquefield [20] found that average long-run real rates of return on investments were closer to 4%. This rate may be more appropriate for long-term forestry investments. Timber investments may also be considered less risky than those in manufacturing and equipment, thus justifying a low discount rate.

The appropriate discount rate for public agencies is also moot. The United States Office of Management and Budget (OMB) has required most federal agencies to use a 10% and 7-5/8% real discount rate in evaluating public projects. In response to these requests, Forest Service economists have also analyzed long-run real returns in stocks and bonds and found them to average somewhat less than 4% [31]; OMB neither approved nor prohibited such rates. Thus, most official Forest Service analyses have used all three discount rates to evaluate returns.

The issue of the correct discount rate is complex. Generally, higher discount rates penalize longer rotations. If corporate or public policy mandates a particular rate, then it should be used. If no policy exists, the 4% real annual before-tax discount rate seems reasonable. Analysts should, of course, keep all costs and benefits in real terms as well, except those that increase or decrease in value at rates different from inflation.

2.2.4 Discounted Cash Flow Table

Once the physical flows and unit values over time have been estimated, they can be used to generate a discounted cash-flow table for each alternative management regime (Fig. 2.1, step 4). The form of the cash-flow table is identical to that of the physical flow table (see Table 2.1). But instead of quantities, the cash-flow table summarizes the costs and returns in dollars, some of which are discounted.

Table 2.4 shows the real before-tax discounted cash-flow for the physical flows of the loblolly pine seedtree management regime shown in Table 2.1, using the input costs from Table 2.2. For public owners, such a before-tax (that is, no income taxes included) analysis is, of course, appropriate.

Table 2.4. Cash flows for loblolly pine seedtree management regime, site index 65, at base age 26. (See Table 2.1 for physical flows.)[1]

	Year								
Activity	0	11	18	21	25	30	32	40	44
	$/ac.($/ha)								
Costs									
Prescribed burn	3.29(8.13)							–	
Scarify site (disk)	60.22(148.80)							–	
Apply herbicides	41.11(101.58)							–	
Prescribed burn		3.29(8.13)	3.29(8.13)		3.29(8.13)		3.29(8.13)		
Timber marking				8.26(20.41)		9.03(22.31)		25.31(62.54)	
Subtotal	104.62(258.52)	3.29(8.13)	3.29(8.13)	8.26(20.48)	3.29(8.13)	9.03(22.31)	3.29(8.13)	25.31(62.54)	
Discounted @ 4%	104.62(258.52)	2.13(5.26)	1.62(4.01)	3.62(8.95)	1.23(3.04)	2.78(6.87)	0.94(2.32)	5.37(13.27)	
Returns									
Commercial thinning									
pulpwood				161.92(400.10)					
chip and saw						243.20(600.95)			
sawtimber						228.97(565.78)			
Final harvest									
chip and saw								246.24(608.46)	
sawtimber								2393.59(5914.56)	
Seedtree harvest									537.92(1329.20)
Subtotal				161.92(400.10)		472.17(1166.73)		2639.38(6521.91)	537.92(1329.20)
Discounted @ 4%				71.06(175.59)		145.58(359.73)		549.75(1358.43)	95.77(236.64)
Net returns	–104.62(–258.52)	–3.29(–8.13)	–3.29(–8.13)	153.66(373.69)	–3.29(–8.13)	463.14(1144.42)	–3.29(–8.13)	2614.07(6459.37)	537.92(1329.20)
Discouted net returns to year 0	–104.62(–258.52)	–2.13(–5.26)	–1.62(–4.01)	67.44(166.64)	–1.23(–3.04)	142.79(352.83)	–0.94(–2.32)	544.48(1345.41)	97.77(241.59)
Cumulative present value	–104.62(–258.52)	–106.37(–262.84)	–108.37(–767.78)	–40.93(–101.13)	–42.16(–104.18)	100.63(248.66)	99.69(246.33)	644.17(1591.74)	739.94(1828.39)

[1] 1 ha = 2.4710 ac.; 1 ac. = 0.4047 ha.

For private owners, after-tax analyses may also be pertinent (see 2.3.2 and 2.3.3 for details on tax treatment). To simplify the illustration, annual property taxes and management charges were omitted, but they should be included in an actual analysis. Land purchase costs and sales returns also were omitted, on the assumption that the investor would own the land anyway.

Real base-year prices for sawtimber, chip-and-saw material, and pulpwood were assumed to be $0.62, $0.38, and $0.23/ft3 ($21.89, $13.42, and $8.12/m3), respectively. All other prices were kept in constant real terms for all subsequent years except those for timber marking and sawtimber. The historical data previously discussed indicated that prices for both had increased at about 1% year more than the inflation rate. To estimate their costs or returns in future years, the analyst would then use the compound interest formula, as in Equation 1 (see 2.2.3.3). For example, the cost of marking trees for thinning would increase from $6.70/ac. ($16.56/ha) in year 0 to $8.26/ac. ($20.41/ha) in year 21. More strikingly, the value of sawtimber would increase from $1607/ac. ($39.71/ha) currently to $2,392/ac. ($5,915/ha) in year 40 (Table 2.4).

Overall, Table 2.4 indicates that the hypothetical regeneration and management regime is quite profitable, yielding a 4% return on the cash invested in growing a stand *plus* $740/ac. ($1,828/ha) in additional present value. Much of this value is attributable to the increase — about 20% — in sawtimber prices alone. Nevertheless, the investment would still be desirable.

2.2.5 Financial Investment Decision Criteria

The discussion of present value of the investment in the cash-flow table presages that of financial investment criteria (Fig. 2.1, step 5). Net present value — the net value of all cash-flows discounted to year 0 at a given discount rate — is one criterion. Internal rate of return, benefit:cost analysis, cost-price, land expectation value, and equivalent annual income are other relevant criteria that consider the time value of money — the fact that cash income or expenses in the future are worth less than they are today. These criteria are examined in detail in Clutter et al. [7], Leuschner [21], Gunter and Haney [18], and Bullard et al. [5], which form the basis for much of this discussion.

2.2.5.1 Formulation

The calculation of a present value of a future sum may be derived from Equation 1 as:

$$V_0 = V_n/(1+i)^n \tag{7}$$

From this, the net present value (NPV) formula for a number of future cash-flows may be derived:

$$\text{NPV} = \sum_{t=0}^{n} \frac{R_t - C_t}{(1+i)^t} \tag{8}$$

where:

R_t = returns (benefits) in year t
C_t = costs (expenses) in year t
n = number of years in rotation
t = number of years since year 0
i = discount rate.

Positive NPVs generally indicate acceptable projects, negative NPVs the converse.

The internal rate of return (IRR) is the annual interest rate that will cause the discounted returns to equal the discounted costs. It may be represented mathematically as:

$$\text{IRR: } i \text{ such that} \quad \sum_{t=0}^{n} \frac{R_t}{(1+i)^t} = \sum_{t=0}^{n} \frac{C_t}{(1+i)^t} \qquad (9)$$

IRRs greater than an owner's required (alternative) rate of return or a corporate hurdle rate (the discount rate used to measure acceptability of a project) are considered acceptable.

The benefit:cost (B:C) ratio, also referred to as the profitability index, measures the value of discounted benefits compared to the value of discounted costs at a given discount rate:

$$B:C = \frac{\sum_{t=0}^{n} R_t/(1+i)^t}{\sum_{t=0}^{n} C_t/(1+i)^t} \qquad (10)$$

B:C ratios > 1 generally indicate investment acceptability, those < 1 the converse. Firms may also set a minimum acceptable B:C value > 1.

Cost-price indicates the product value required in the future to equal a specified return on an initial investment. It compounds all current costs into the future — such as at harvest time — and estimates the total value the harvest would have to equal for the investor to achieve a specified rate of return. It may be shown mathematically as:

Coct-nrire• P and n curl, that

$$\sum_{t=0}^{n} C_t(1+i)^{n-t} = P_n \cdot Q_n \qquad (11)$$

where:

P_n = product price per unit of volume required at the end of the rotation to equal the costs compounded at interest rate i for yield Q_n.
Q_n = yield required at the end of the rotation to equal the costs compounded at interest rate i for product price P_n.

Cost-price does not give an accept-reject decision per se. Instead, it indicates the total value of the compounded investment costs at the end of the period (rotation). The returns required at the end of the rotation can be calculated on a per-unit basis by dividing total compounded cost by either yields or expected price per unit. The analyst must then compare the expected yield or price values to determine if they seem reasonable — that is, achievable.

The land expectation value (LEV) — also called the Faustmann formula, soil expectation value, or bare land value — is actually an NPV calculation, only for an infinite number of *identical* rotations rather than just one rotation. If the net present value of one rotation has been determined, that value can be simply used as follows:

$$\text{LEV} = \text{NPV} + \{\text{NPV}/[(1+i)^n - 1]\} \qquad (12)$$

LEV provides a measure of the total value of that management regime maintained in perpetuity at the given discount rate — that is, the value an owner could pay for land in year 0 and still receive the given interest rate. The measure is handy because it allows the analyst to compare the present value of various management regimes that may have different rotation ages. An LEV > 0 indicates an acceptable rate of return, an LEV < 0 an unacceptable one. Note that it is actually a mathematical relationship that can determine the present value of *any* set of perpetual, identical cash-flows, not just the value of land.

Finally, the equivalent annual income (EAI), also referred to as land rent or soil rent, provides a measure of the annual payments an owner would receive to realize a given NPV at a given discount rate. For an annual income to be received in perpetuity starting in year 1, EAI is determined by multiplying LEV by the interest rate in decimal form:

$$\text{EAI} = \text{LEV}\ (i) \qquad (13)$$

If LEV is positive, then EAI will be positive, and vice versa. As a stand-alone criterion, a positive EAI would imply acceptance of the investment at the given discount rate. Its more useful application, however, is in comparing that annual income with the one that might be received from other alternatives, such as farming.

Table 2.5 summarizes the preceding formulae and their applications. The next section discusses their use in capital budgeting.

2.2.5.2 Capital budgeting

Capital budgeting — the financial process firms or agencies employ to decide among competing projects — may entail the use of either undiscounted measures of performance, such as payback period or return on assets, or discounted measures, such as NPV or IRR. The discussion here has focused on discounted cash-flow criteria for evaluating project desirability because they are almost universally considered superior to nondiscounted measures, particularly in the case of long-term investments such as forestry. But there is some debate regarding the merits of each.

To simply determine whether a project is acceptable or not, any discounted cash-flow criterion will give satisfactory results. Given a known discount rate, a positive NPV, LEV, or EAI would indicate a desirable investment. This implies the investment is returning the desired discount rate or hurdle rate, plus additional present value. A negative NPV, LEV, or EAI would indicate the project is unacceptable. Any investment that has an IRR equal to or greater than the corporate, agency, or individual required alterna-

Table 2.5. Summary of formulae for financial investment criteria used in economic analyses.

Criterion	Equation in text	Formula	Application
Future value of present payment	(1)	$V_n = V_0 (1 + i)^n$	Calculate a single future value
Present value of future payment	(7)	$V_0 = V_n / (1 + i)^n$	Calculate a single present value
Simple internal rate of return	(4)	$i = (V_n / V_0)^{1/n} - 1$	Calculate a simple rate of return for two cash flows
Net present value (NPV)	(8)	$\sum_{t=0}^{n} \frac{R_t - C_t}{(1+i)^t}$	Calculate the present value of many cash flows
Internal rate of return (IRR)	(9)	i such that $\sum_{t=0}^{n} \frac{R_t}{(1+i)^t} = \sum_{t=0}^{n} \frac{C_t}{(1+i)^t}$	Calculate the rate of return for many cash flows
Benefit: cost ratio (B:C)	(10)	$\frac{\sum_{t=0}^{n} R_t/(1+i)^t}{\sum_{t=0}^{n} C_t/(1+i)^t}$	Calculate the ratio of discounted benefits to discounted costs
Cost-price	(11)	P_n and Q_n such that $\sum_{t=0}^{n} C_t(1+i)^{n-t} = P_n \cdot Q_n$	Calculate the future value of returns needed in the final year of the rotation (n) to equal compounded costs
Land expectation value (LEV)	(12)	NPV + [NPV/ [$(I + i)^n - 1$]]	Calculate the present value of an infinite number of identical periodic cash flows
Equivalent annual income (EAI)	(13)	LEV(i)	Calculate the perpetual annual equivalent of an infinite number of periodic payments

where:
V_0 = value in year 0
V_n = value in year n
R_t = return in year t
C_t = costs in year t
P_n = price per unit of product in year n
Q_n = yield of product in year n
i = interest (discount) rate
t = number of years since year 0
n = number of years in rotation.

tive rate of return is an acceptable project, as is any investment with a B:C ratio > 1; and vice versa.

To choose among competing projects with a limited budget, NPV is generally recommended as superior in most financial textbooks (i.e., Brealey and Myers [3], Weston and Brigham [40]). For investors who can clearly determine their discount rate, maximizing NPV for their firm or agency is the best way to maximize profits and worth. Quite clearly, the competing project that has the greatest positive NPV would be preferred; projects would be selected in order until the capital budget was expended. A positive NPV will indicate to investors whether they receive their desired rate of return and the amount of extra present value of the future cash-flows.

One disadvantage of NPV is that it does not directly account for project scale, i.e., large investment projects would be expected to have greater NPVs than smaller projects. Another disadvantage is that it does not account for the effects of different time horizons, i.e., the NPV of a long-term investment with years of cash-flow would be expected to be greater than that of a short-term project. However, these disadvantages of NPV can be overcome by using LEV instead, which measures the discounted value in perpetuity of identical costs and benefits (thus always comparing similar time horizons) on a given tract or per-unit basis (thus always comparing projects of the same scale). Therefore, LEV may be the preferred criterion from a theoretical standpoint if the discount rate is known, even though the problem of unequal project sizes might still remain.

One practical problem with both NPV and LEV is explaining their application to NIPF landowners, or even corporate management. The concept of receiving a rate of return plus a present value of additional cash is somewhat difficult to understand and relate to, compared to the more intuitive IRR. Additionally, whereas corporations and public agencies may have standard discount rates, NIPF landowners seldom think in terms of their "discount rate" or "alternative rate of return" for forest investments.

IRR is usually considered a theoretically inferior criterion for at least three reasons. First, if the cumulative cash-flows change from negative to positive, then positive to negative, and so on, there may be multiple internal rates of return. Second, IRR assumes that all intermediate cash-flows are reinvested at the internal interest rate. For investments with large rates of return, this may be unrealistic, because intermediate cash-flows may receive more or less interest than the internal rate. Both of these drawbacks are probably not often serious in investment analyses in practical forestry situations.

Third, it is quite possible for a given cash-flow pattern to be less desirable than another at the given discount rate, but still have a greater internal rate of return. This drawback to using IRR may be quite serious. For example, a short-lived investment with modest returns may yield a greater IRR than a long-lived project with similar costs and greater returns. However, at a low discount rate, such as 3 to 4%, the one with the greater future returns may have a greater NPV. Thus it is important to use NPV or LEV rather than IRR, if the discount rate is known in advance.

Despite its theoretical drawbacks, IRR has many advocates. Many people think it is easier to understand and explain. One can quickly compare an IRR with the annual rate of return of a savings account, the annual percentage rate of a loan, or any other investment alternative. Lacking a fixed discount rate, owners can more easily use IRR to judge whether the returns seem adequate, given the risk involved and their objectives.

IRR also offers advantages with respect to the problems of project size and duration encountered with NPV. Although LEV may handle these problems well in forest regeneration and management decisions, it is not widely applied or understood in forest products firms or public agencies. Instead, IRR, which can be calculated for most investments, is used to determine investment desirability and then project ranking until the capital budget is expended.

B:C ratio, which, like NPV and LEV, requires that the discount rate be known in advance, offers a method of dealing with unequal project size and duration, while dealing with a known opportunity cost of capital. Again, projects would be ranked in order (according to their B:C ratios) and the highest selected until the capital budget was expended. However, using the B:C approach would not necessarily maximize the present value of a firm's or an agency's investment dollars.

In practice, IRR and NPV are used most frequently. A recent survey found that most forest-products firms used IRR as their primary investment criterion, followed by NPV [12, 30]. The Forest Service uses NPV in their Resources Planning Act analyses. For most forestry and regeneration investments, all criteria will usually yield similar rankings of investment alternatives, as was found by Mills and Dixon [26]. Because most computer programs now calculate all of these criteria for any investment, results can be compared and the most reasonable outcome chosen.

For the cash-flow shown in Table 2.4, most of the preceding criteria could be calculated as previously described (see Table 2.5). However, LEV presents two problems. First, the "rotations" in a seedtree (or shelterwood) system overlap — the final seedtree cut occurs after the new stand has been established. Thus one does not have a series of stands with identical rotations (where the beginning of the second starts at the end of the first, and so on). This problem can be overcome by discounting the value of cutting the residual seedtrees back 4 years in this case — to the year of final harvest — at the given discount rate. Once this has been done, the standard NPV or LEV formulation can be applied.

Second, LEV requires a perpetual series of *identical* costs and returns for each rotation. This problem is more intractable than the first. If there are real cost or price increases, costs and returns will differ each rotation. This is particularly difficult because the effect of any real net price (or cost) increase, carried to infinity, is to make the LEV infinitely positive (or infinitely negative). To apply this concept in practice, then, the analyst must use all constant costs, or assume that real price changes will occur only throughout one rotation and that all subsequent rotations will have identical annual costs and returns. Usually, analysts ignore real price increases in future rotations since their present value is typically not large. Thus the discounted cash-flow results will not be affected deleteriously.

The value of all criteria, except cost-price, can be calculated as follows given the data in Table 2.4 and the equations in Table 2.5:

NPV at 4% = \$739.94/ac.	(Equation 8)
LEV at 4% (assuming constant costs and returns) = \$894.06/ac.	(Equation 12)
IRR = 10.2%	(Equation 9)
B:C ratio = 7.05	(Equation 10)
EAI = \$36.01/ac.	(Equation 13)

This investment looks quite attractive using a 4% real discount rate (NPV > \$700, LEV nearly \$900). Note that all rotations after the first only contribute about \$150 more in present value (\$894 — \$740); this is because the discounting, even at a low 4%, makes incomes beyond 40 years worth very little in year zero. At the 4% rate, the B:C ratio indicates that the discounted benefits are roughly 7 times greater than the discounted costs. The IRR of roughly 10% is the rate at which discounted benefits would equal discounted costs. The equivalent annual income of \$36/ac. could be compared with other land uses, such as the *net* return from crops (prices x yields — planting costs), to determine the most profitable uses.

The preceding example provides measures of return for one possible management regime. As an individual project, one should make the investment at a 4% discount rate since it had a positive NPV and LEV. The investment should be compared with other regeneration and management alternatives as well, assuming it will stay in forestland. LEV is best to use for evaluating among forest investments since it can account for differences in rotation ages. Corporate management is likely to prefer internal rate of return or net present value. NIPF landowners would probably understand IRR best, which can be compared to savings accounts or certificates of deposit. Farmers may relate best to EAI when comparing timber returns to crop returns.

2.2.5.3 Sensitivity analyses

The previously discussed methods (physical flow, cash-flow, and capital budgeting) provide the analyst with an estimate of costs and returns based on the best information available. Because some of the information in the analysis may not be definitive, however, most analysts vary these factors to see what changes may make a difference in the outcome (Fig. 2.1, step 5). For example, if price or yield information is not well known, these factors could be varied by 10 or 20% to test whether NPV would be significantly affected.

2.2.5.4 After-tax analyses

The preceding discussion used a before-tax approach. For many applications, this type of analysis alone is preferable. Indeed, for public agencies or nonprofit institutions, taxes are not relevant. Even owners with taxable investments should determine costs and returns on a before-tax basis first because investments that are superior on that basis will probably remain so even if tax laws change. In fact, many investors in forest regeneration and management feel that all investments should show good before-tax returns to prevent unnecessary risk due to continual tax-law revisions.

The preceding before-tax analysis included property tax, which is often considered a management expense. But it excluded effects of federal and state income taxes, which are most likely to alter overall returns. Income tax costs (harvest expenses) and benefits (reforestation tax credits or deductions, and management expense deductions) should be included in the cash flow table at the appropriate time in an after-tax analysis; moreover, an after-tax discount rate should be used (see 2.3.2 for details).

2.2.5.5 Recommendations and decisions

The last step in the economic analysis of regeneration options is that of making recommendations to decision-makers (Fig. 2.1, step 6). In some cases, foresters will both analyze and decide; in others, they will recommend to supervisors. In both cases, supporting documentation should include the materials previously discussed — physical flow tables, cash-flow tables, investment-criteria calculations, and sensitivity analyses. Some text explaining the alternatives considered and selected, and both the quantifiable and subjective reasons and risks, would also be appropriate. Together, these will help decisionmakers to select the best option, budget for the regeneration, and anticipate cash-flows.

2.3 Public Policy Influences

In the preceding examples, public policies or their impact on financial returns were not considered. In practice, however, many public policies significantly affect costs of forest regeneration and management and, to a lesser extent, timber prices.

2.3.1 Public Regulation

In addition to biological and economic criteria, southern pine regeneration decisions may also be affected by public regulation. For example, regulations in some southern states require that seedtrees be left to ensure stand regeneration. Federal legislation has spawned a series of state voluntary mechanisms to meet water quality goals, such as Section 208 area-wide nonpoint source pollution planning and best management practices (see 2.3.1.2). It has also led to increased regulation of operations in wetlands.

2.3.1.1 Seedtree laws

At least five states that grow southern pine species have laws that address the leaving of pine seedtrees after harvest to ensure regeneration. Two of these laws — in Louisiana and Florida — are not rigorous and have not been used. Mississippi's law could affect forestry operations to a significant degree if implemented aggressively. But enforcement has been delegated to county sheriffs, who may not even be aware of the law.

Virginia's seedtree law, which requires leaving two 14-in. (36 cm) tulip poplar *(Liriodendron tulipifera* L.) trees and eight 14-in. (36 cm) or greater pine trees per ac. on harvest sites where these species predominate, has been enforced consistently. Alternately, landowners can enter into a regeneration contract with the state, in which they guarantee that the harvested land will be artificially regenerated.

A 1977 Maryland seedtree law, patterned after the 1950 Virginia law, requires that eight pine seedtrees 14 in. dbh or larger per ac. be left on predominantly pine harvest sites. Penalties for violations may consist of fines and reimbursement charges for state-performed compliance costs. In lieu of leaving seedtrees, landowners may provide for reforestation by having a management plan approved before harvest begins. The law has generally been adequately enforced.

Requirements for leaving seedtrees in Virginia and Maryland dictate that natural regeneration be encouraged, at the least. However, because the cost of leaving seedtrees may be greater than the cost of cutting all timber and replanting — an acceptable alternative — some landowners may prefer to plant.

2.3.1.2 Federal water and air quality laws

Federal water and air quality laws also could affect regeneration practices indirectly. The federal Water Quality Act (WQA), which comprises major water-quality amendments enacted in 1972, 1977, and 1987, mandates control of point and nonpoint source water pollution. Point source pollution is that which has a discrete origin and emission, such as industrial effluent, or runoff from agricultural feedlots or drainage ditches. Nonpoint source pollution is that which does not have a discrete origin, but rather comes from a widespread land area such as that used for crops, mining, or timber harvesting.

Point source pollution is regulated by Section 404 of the WQA, nonpoint source pollution by Sections 208 and 319 (the new 1987 amendments). Sections 208 and 319 mandate that individual states develop and implement water-quality management plans, subject to approval of the federal Environmental Protection Agency, which designates silvicultural activities as one source of nonpoint pollution that must be addressed. The 208 plans led to development of Best Management Practices (BMPs), the forest management, harvesting, and regeneration procedures established by most southern state forestry agencies and industry associations to minimize adverse impacts of forestry operations on water quality. BMPs are voluntary to date, but some are promoted and monitored more aggressively than others.

Certain forest-management activities are also regulated under Section 404, which requires a permit from the Army Corps of Engineers before dredging and filling in navigable waters and adjacent wetlands. Current Section 404 regulations continue to exempt normal silvicultural activities from permit requirements, but state that "Activities which bring an area into farming, silviculture, or ranching use are not part of an established operation" and therefore are not exempt from permit requirements. Additionally, although normal harvesting is exempt, "the construction of farm, forest, or ranch roads" is not included. Roads and skid trails which meet the BMP guidelines established under the 208 plans may be exempt if they meet several additional Section 404 criteria: they must be minimized in number, width, and length; located sufficiently far from streams or other water bodies; bridged or cub.'erted so as to not impede expected flood flows; properly maintained and stabilized to prevent erosion; and able to meet other requirements.

Many counties and states in the South have considered or enacted air quality laws that restrict prescribed burning in some fashion. Burning is usually not prohibited, but is permitted only with prior notice of public officials and under predetermined weather conditions. Such restrictions could add costs to both artificial and natural regeneration, and may tend to favor increased use of chemical site preparation (herbicides). Most managers should be familiar with these laws in their districts and able to gauge their effect on type of practices required and additional costs, if any.

2.3.2 Federal Income Taxes

Because the effects of federal and state income taxes on forestry investments are complex and constantly changing, they are explained only briefly here. This section merely describes 1988 federal law. Many state laws are based on federal law but vary so much among states that no generalizations will be made here.

2.3.2.1 Personal and corporate income taxes

Before 1987, income from timber growing and sales was taxed under the capital gains provisions of the federal tax law. This code allowed timber income to be taxed at more favorable rates than ordinary income, similar to the treatment for investments in stocks. For individuals, capital gains income was subject to a 60% exclusion. Thus, only 40% of the gain was taxed. For example, individuals who were typically taxed at the 50% maximum marginal rate on ordinary income would pay only (40%) x (50%), or 20%, on timber sale income and other capital gains. (The marginal tax refers to the tax rate on the last amount of income earned — the highest tax rate an individual or firm pays.) There was no exclusion for corporations, but there was a tax rate differential between ordinary income (46% marginal tax rate) and capital gains (28% marginal tax rate); this tax treatment was intended to and did benefit investors in a long-term endeavor such as timber growing. However, the tax reform legislation of 1986 eliminated the differential by 1988.

Timber income is now (as of 1988) taxed at the same rate as ordinary income. Individuals would be taxed at their current marginal income rate, either 15 or 28% of sale income less the cost basis of timber sold (capitalized expenses) at the time of sale. Corporations are taxed at the new standard corporate rate of 34%. As with the prior tax law, individuals and corporations must also "capitalize" their regeneration expenses — that is, record any costs for site preparation, planting, and vegetation control and carry these costs on the books until harvest, when they are deducted from harvest income as a cost of timber sold. Alternatively, the first $10,000 of reforestation expenses may be amortized over an 84-month period (see section 2.3.2.2). Any harvest sale costs, such as timber marking charges, advertising expenses, or consulting fees, may also be deducted from stumpage returns. Income tax must then be paid on the net amounts. This treatment of capitalizing regeneration costs was consistent with both the pre- and post-1986 tax revision.

Before the 1986 law, all corporate and individual forest landowners could "expense" management costs — that is, deduct the costs of management, such as property taxes, administration, and timber stand maintenance from their income taxes in that current year. When management costs cannot be expensed, they must be capitalized. If intermediate harvests are made, capitalized expenses can be deducted then as well. Regeneration costs must be capitalized, but management costs may be expensed.

Corporate owners may still expense management costs in 1988, as well as any interest costs incurred. The new law, however, also attempted to eliminate, through the use of passive loss rules, the practice of deducting expenses of one activity against income earned from other sources. The status of taxpayers may fall into at least three categories, depending on how the U.S. Internal Revenue Service perceives their activities.

(1) Active trade or business: All management costs, property taxes, and interest are fully deductible against income from any source if the owner "materially participates" in timber management activities.

(2) Investment: Expenses can be recovered as miscellaneous itemized deductions to the extent they exceed 2% of adjusted gross income — similar to the floor for charitable contributions — or they can be capitalized as carrying charges. The latter avoids the permanent loss of the deductions that fall below the 2% floor. However, landowners cannot both expense and capitalize in the same year. Property taxes are deductible against income from any source. In addition, interest on debt incurred to buy or carry property held for investment is limited to net invest-

ment income for the year.

(3) Passive trade or business: Expenses can only be offset against passive income. However, any net passive loss can be carried forward to be recovered against future passive income.

Determining passive and active status for **NIPF** landowners is complex and still evolving. Limited partnerships clearly are passive. Absentee owners who receive most income from other sources — such as doctors, lawyers, or airline pilots — would probably be considered investors, rather than in the trade or business. Farmers who manage and harvest their timber as part of a farming enterprise are likely to qualify as active in the trade or business. However, these generalizations may vary considerably from case to case.

An analyst should determine the probable taxable status of the investor and include discounted cash-flows accordingly. Regeneration expenses should be carried through to harvest and deducted as a cost of timber sold before taxable income can be determined (unless the owner elects to amortize up to $10,000 in reforestation expenses). Management-expense deductions can be entered as a return in the current year if they qualify; otherwise, they must be added to the cost basis, carried forward, and subtracted from harvest revenues.

If owners make intermediate harvests in a stand, they may subtract capitalized expenses from stumpage returns. The proportion of total merchantable volume removed to total merchantable volume of the stand determines the allowable expenses **of** sale. For example, if one-third of the merchantable volume were removed in a thinning at age 15 and the cost basis attributable to site preparation and planting was $180/ac. ($445/ha), then the owner could deduct $60/ac. ($148/ha) for the cost of timber sale from the stumpage returns per unit area. The unused or adjusted cost basis of $120/ac. ($297/ha) would be carried forward for recovery against revenue from future timber harvests.

2.3.2.2 Reforestation tax credits and deductions

All landowners (except trusts) may also receive federal tax credits and amortization deductions for reforestation expenses planting trees under the "Packwood Amendment" — part of the 1980 Recreational Boating and Safety Act (Title **III -** Reforestation). The legislation allows a 10% investment credit and an amortized deduction for annual reforestation expenses of up to $10,000/year. Thus, the investment credit cannot exceed $1,000 annually, which effectively limits the program to **NIPF** investors. The amortized deduction requires that one-fourteenth of the investment be deducted in the first year, one-seventh in the second through seventh years, and one-fourteenth in the eighth year. If both the investment credit and amortization are selected, the amortizable amount must be reduced by one-half the credit taken. For example, a $1,000 reforestation investment would allow a 10% credit of $100 and an amortizable basis of $950. The election to amortize also means that owners cannot deduct these establishment costs from the cost of the sale at the end of the rotation; this would be a double (and unallowable) benefit.

2.3.2.3 After-tax discount rates

If a discounted cash-flow is calculated after taxes, some analysts also recommend use of an after-tax discount rate. This rate explicitly takes into account the fact that cash-flows in each year are affected by taxes, and is analogous to the difference between real and nominal discount rates.

An after-tax discount rate for an owner is determined by multiplying the nominal discount rate by the effective percentage of income received:

$$\text{After-tax discount rate} = \left(\text{Before-tax discount rate}\right)\left(1 - \text{Marginal tax rate}\right) \quad (14)$$

For example, an NIPF landowner in the 28% tax bracket (marginal tax rate) with a 10% nominal discount rate would have an after-tax rate of (0.10) (1–0.28) = 0.72 = 7.2%.

To calculate a real after-tax discount rate, the nominal after-tax rate would first be calculated and then converted to a real rate with the following formula:

$$i_{at} = \frac{\{1 + [(1-t)k_{bt}]\}}{(1+j)} - 1 \quad (15)$$

where:

i_{at} = real discount rate after tax
k_{bt} = nominal discount rate before tax
t = marginal tax rate
j = rate of inflation with all rates expressed as decimal.

The use of after-tax discount rates often has the curious effect of increasing the NPV of an investment. This seems anomalous, but is due to the lower discount rate. Although returns may be lower because of taxes, the lower discount rate makes the present value of the investment larger than it would be at the before-tax rate. This result and the difficulty in understanding after-tax discount rates have led to their limited use. The IRR for after-tax cash-flows would be the same no matter what discount rates were used.

2.3.3 Financial Incentives

In addition to regulatory and tax policies, federal and state governments also provide many other services and programs designed to encourage regeneration. These range from direct financial assistance provided by the Forestry Incentives Program (see 2.3.3.2) to indirect technical assistance provided by state foresters to **NIPF** landowners. Most other financial incentives are targeted for **NIPF** landowners rather than forest industry, as will be apparent in the following discussion.

2.3.3.1 Agricultural Conservation Program

The Agricultural Conservation Program (ACP) is a general farm program designed to promote many resource-conserving practices, including tree planting, timber stand improvement, and wildlife habitat improvement. Landowners performing these or other conservation practices may receive partial reimbursements called cost-share payments through the county office of the Agricultural Stabilization and Conservation Office (ASCS).

ACP cost-share payments can easily be included in a regeneration cash-flow analysis. A nonindustrial farm or forest owner must first determine if the lands are eligible, whether the county has funds available, and the current cost-share rate. If funding is available, it may be included in the cash-flow analysis as a return in the year of planting or timber stand improvement. For example, if planting costs were $180/ac. ($445/ha) and the ASCS would cost-share at a 50% rate, a landowner would include a $90 return in the first year as well. Alternately, the planting costs could just be reduced by $90, and the results in the cash-flow analysis would be the same.

Cost-share payments received under ACP may be taxed two ways, at the landowner's election [28]. First, they may be included as taxable income. If owners so elect, they may then receive full benefits for the reforestation tax credits and deductions if they take advantage of these provisions. Second, a portion of the cost-share payments may be excluded from taxable income. If owners so elect, then they can only claim reforestation tax credits and deductions on the taxable portion of the cost-share payments, not on the excluded amount. Determining which of these tax elections is preferable depends wholly on the landowner's situation and must be evaluated on a case-by-case basis.

2.3.3.2 Forestry Incentives Program

ACP funds for tree planting and timber stand improvement dwindled in the 1960s because of increasing competition for the available funds and the reluctance of ASCS county boards oriented to farm management to approve forestry practices. Faced with needs for a better funding base, forestry interest groups successfully lobbied Congress for a separate cost-share program for forestry practices. Congress enacted the Forestry Incentives Program (FIP) attached as a rider (Title X) to the Agriculture and Consumer Protection Act of 1973 [14].

The FIP program authorizes cost-share payments for reforestation and timber stand improvement, site preparation for natural regeneration, and firebreak construction. ASCS is charged with program administration, and the Forest Service is responsible for technical assistance, provided by state forestry agencies via cooperative agreements with the Forest Service. State landowner assistance (service) foresters must approve the plans before practices can be implemented, and the county ASCS committee must decide which of the many applicants will receive funding. Service foresters must also approve performance before payment is made. The federal cost-share rate is determined by each state; commonly 50% in the South, it ranges up to 65%.

FIP payments are treated the same as ACP payments in regeneration cash-flows. Cost-share funds, if available, are considered a receipt in the year of the activity. Again, this obviously improves regeneration profitability. Tax treatment of FIP and ACP payments also is the same.

2.3.3.3 State cost-share programs

As of 1987, seven states in the South had developed some type of public or private cost-sharing program designed to encourage good forest management by NIPF landowners [34]. Most of these programs focus their efforts and expenditures on regeneration of southern pine. The cash-flows would be treated the same as they are for the federal cost-share programs. Analysts can obtain current details on qualifying ownerships, funding limits, tract size requirements, and other program stipulations from their state forestry agencies.

The Alabama Resource Conservation Program, begun in late 1985, provides cost-sharing at the 60% level, up to a maximum payment of $3,500 per landowner per year. Eligible practices are tree planting, site preparation for tree planting or natural regeneration, and timber stand improvement. Florida's private forest industry underwrites the Florida Reforestation Incentives Program with contributions of pine seedlings to NIPF landowners. The Mississippi Forest Resource Development Act, which went into effect in 1974, provides cost-share payments not to exceed 50% to NIPF landowners who establish or improve a stand of forest trees and for timber and game management.

The North Carolina Forest Development Program, enacted in 1977, provides cost-share assistance to private woodland owners at 40% of prevailing rates set each year. South Carolina's Forest Renewal Program provides cost-share funds of up to 50%. Lands qualifying for the federal FIP may not receive assistance. Allowable practices include tree planting, timber stand improvement, site preparation, and natural regeneration. The Texas Reforestation Foundation is privately funded by voluntary contributions from forest industry, assessed on the basis of a rate per ton of pine or hardwood harvested. Administered by the Texas Forestry Association, funds are paid to NIPF landowners on a matching basis. The 1970 Virginia Plan, or Reforestation of Timberlands Program, is designed to bring non-forest or hardwood forestland into pine production [16]. In 1985, incentive payments of 50% of total costs or up to $60/ac. ($148/ha) could be made [19].

2.3.3.4 Conservation Reserve Program

In 1985, the Food Security Act, better known as the Farm Bill, authorized a modern Conservation Reserve (Soil Bank) Program for the crop years 1986 to 1990. Cumulative reserve lands were initially intended to equal not less than 40 million and not more than 45 million ac. in the United States. At least one-eighth of this land, some 5 million ac. (2 million ha), was to be planted in trees. Owners or operators (land ownership was not required) could contract with the Secretary of Agriculture and become reserve producers. Applicants must have owned or operated the land for at least 3 years or since January 1, 1985, unless acquisition was by will or succession, and must have shown that control of the land would be retained for the contract period.

Most establishment costs, shared by the government and the producer, were to be based on a flat rate for a particular practice. Annual rental payments to producers were to be made for 10 years under the conservation contracts to maintain the designated cover. Annual payments were determined through competitive bidding; all bids were placed in a pool, and the lowest bids accepted first.

The first three sign-ups in 1986 and 1987 resulted in almost 9 million ac. enrolled in conservation reserves. Of these, only 560,000 ac. were to be planted in trees, 96% of which was to occur in the South. Accepted bids ranged up to $90/ac. nationally; most accepted tree-planting bids approximated the average (about $45/ac., or $111/ha) [10].

Payments under the Conservation Reserve Program would be included as cash returns in the year received. Initial planting costs would be reimbursed in the initial year. The yearly rental payments from successful bidders would be included as returns for each of the next 10 years. With the 1986-87 average accepted bids of about $45/ac. per year, it is obvious that financial returns for lands qualifying under the Conservation Reserve Program would be greatly improved.

2.3.3.5 State technical assistance and seedlings

The states also provide indirect assistance in forest management and regeneration to NIPF landowners. State service foresters give advice on harvesting, timber stand improvement, and regeneration, usually at no charge. Most states in the South limit the number of days of assistance that a state forester can provide to any one owner to prevent duplication of consulting services. However, even a few days of free advice about regeneration can be quite helpful in minimizing the costs on small tracts. A few states also provide limited timber-marking assistance.

In addition to technical advice, all states in the South also grow and distribute seedlings for planting. Costs for growing seedlings are generally more than the prices charged, so landowners benefit from these services as well. Some states also distribute seeds for direct seeding. State programs protect regenerated and mature stands from wildfires, at no direct cost to landowners, and state forestry agencies often help with prescribed burning by plowing fire lines around tracts to be burned, either at a subsidized cost or at no cost. The goal of most of these programs is to increase timber supplies, which should benefit most owners, the forest industry, and the public.

All of these services provided by state forestry agencies reduce forest regeneration and management costs below the levels market equilibrium alone would dictate. They usually are a benefit to NIPF landowners and make the eventual returns from timber sales more attractive. In cash-flow analyses, the landowner should merely include the actual cost of the seedlings, foresters, fire protection, and so on as they occur and are paid.

2.3.3.6 Private forestry assistance

In addition to public programs, technical forestry assistance is also now offered by many private consultants and forest products firms. Consulting forestry services available to private landowners have increased greatly in the last 20 years. Currently, it is estimated that there are over 1,900 consulting foresters in the United States; Georgia has the largest concentration with over 100 known consultants [15]. In addition, many forest industries have begun formal management assistance or landowner assistance programs in areas around their mill. They also lease a large amount of forestland in the South.

A number of surveys have been performed to estimate the extent of private forestry assistance to NIPF landowners. Studies begun at the Southern Forest Experiment Station have been continued by others until the present. Leasing programs began in the 1940s and 1950s; in these, industry leases NIPF land and generally manages it as if it were their own. The area under lease in the South seemed to peak at about 6.7 million ac. (2.7 million ha) [33] in 1970. However, current surveys indicate that this declined to about 4,661,000 ac. in 1982 [24]. Average tract size under lease was 2,078 ac. (841 ha).

Industrial forest-management assistance programs also aid NIPF landowners with forest regeneration, timber stand improvement, and harvesting, in addition to leasing programs. Land management practices may be performed at cost for private landowners. Programs generally require that treated tracts be of a minimum size and within a maximum distance of the mill, and some require first refusal rights — that is, the right to meet or exceed any other firm's bid — when participating landowners sell timber [6, 13]. Land enrolled in formal industrial management assistance programs has increased steadily. In 1984, Meyer and Klemperer [24] found that total enrollment included 4,214,000 ac. (1,705,400 ha) in the South, the largest programs in the West Gulf. Average tract size was 484 ac. (196 ha).

Regional and national surveys have found a steadily increasing number of private forestry consultants through the 1970s and 1980s. Forestry consultants provide services similar to those of state foresters for a fee. In addition, they can provide detailed assistance in timber marking, land surveying, timber and land sales negotiations, and many other forestry practices considered inappropriate for state foresters.

Again, any advantages received from private technical assistance should be reflected directly in cash-flows. If industrial assistance programs reduce site preparation and planting costs for NIPF owners, these costs should be entered as such in the cash-flow analyses. Annual lease payments and fees of consulting foresters should be entered as they occur. The expected benefits from private technical assistance, such as greater yields or higher sales prices, should be included accordingly in the returns.

2.4 Costs and Benefits of Various Regeneration Methods

The preceding general outline for performing economic analyses can be applied to any type of regeneration and management regime for growing southern pines. This section briefly discusses the costs and benefits incurred with each type of regeneration. (See chapter 3, this volume, for details on the different regeneration options.)

2.4.1 Unplanned Natural Regeneration

Natural succession — a polite term for totally unplanned regeneration — has obvious economic costs and returns. Some landowners try to maximize current harvest returns and minimize current expenses, without regard to future stand conditions or returns. With such an objective, clearcutting and then spending nothing to regenerate the site is a rational method. Although this may be beneficial in the short term, it is likely to be costly in the long run.

Essentially, an unplanned, naturally regenerated clearcut will favor stand conversion to less commercially desirable hardwood species rather than retention of pines. For areas likely to be removed from commercial timber production in the future — such as those near expanding cities, prospective reservoirs, highways, or powerlines — maximizing the current net receipts will also maximize "long-term" land receipts. Many landowners may prefer hardwood species for aesthetic reasons or for the better habitat for some game species. Some simply do not like to spend money now for distant future returns.

Unplanned natural regeneration usually will not lead to long-term dollar maximization of productive timberland. Landowners who hold commercial timberland for extended periods of time must continue to pay property taxes, at the very least, which can best be offset with periodic incomes from timber or hunting leases. Usually in the South, sites suitable for southern pine will not grow high-quality hardwoods. Thus, both the growth rates and value of stands left after commercial clearcuts will be small. Moreover, harvests, of mostly hardwood species, will not occur until far into the future, and the value of those harvests will be a fraction of that possible with planned pine regeneration. Similarly, the discounted net present value of any future returns will be comparatively small, given any reasonable discount rate. Only at high discount rates — say, 10 to 15% real — are larger current and smaller future incomes likely to be more economic than well-distributed, moderate incomes over time.

Income-tax considerations also favor natural regeneration, or any other method that minimizes stand establishment costs. Federal income tax law requires owners to capitalize their stand establishment costs — that is, carry them through to the end of the rotation and then deduct them from the sale proceeds as a cost of the sale to determine taxable income. Precommercial thinning, on the other hand, is considered a stand management cost, deductible in the year incurred against income in that year, at least for forest landowners the Internal Revenue Service classifies as actively in the trade or business. The discounted value of the benefits of receiving capitalized deductions far in the future when a stand is cut is far less than that of receiving them as deductions in the current year. The net effect of this tax treatment tends to favor minimizing amortized establishment costs, such as plantations require, and instead incurring costs such as those of timber stand maintenance, which are deductible as they are incurred. Passive trade or business owners, a class which clearly includes limited partnerships, cannot even deduct current management expenses, but must carry them forward to the time of sale or receipt of other passive income. Nonindustrial private landowners may qualify as active, rather than passive, if they materially participate in the forestry business decisions. However, this determination is complex and still evolving. Natural regeneration is apt to have tax advantages in most instances, regardless of whether the landowner is classified as an investor or as actively or passively in the trade or business. Even if owners have to capitalize all management expenses, deferring them will be better on a discounted cash-flow basis than incurring them all at the time of stand establishment.

Lastly, the approach of "cut and get out" is an anathema to foresters and the forestry community. Surveys of NIPF landowners in the South, however, still indicate that only about one-third actively regenerate their pine lands [32]. This suggests that the benefits of maintaining pine stands are not as great as many discounted cash-flow analyses would indicate, that owners are not aware of these benefits, or that owners would prefer to spend or save harvest incomes rather than reinvest in timber production. The high initial costs of planned regeneration and the remote future incomes are often cited as deterrents to NIPF investments. This lack of regeneration would seem to indicate that free markets alone do not provide enough incentive to grow desirable pine timber supplies, which is one of the bases for the host of public forestry programs previously described.

Overall, the economic advantage of unplanned regeneration is short-term maximization of economic returns — but at the expense of long-term gains and, perhaps, land stewardship. NIPF owners may prefer short-term considerations because of needs for immediate cash or of high discount rates; low discount rates, in contrast, favor investments with large future returns. Most industrial forest landowners do not practice unplanned regeneration, although some may on certain sites, particularly those they do not anticipate retaining or have shifted out of their planned mill procurement zones. In most cases, they practice artificial or planned natural or artificial regeneration.

2.4.2 Planned Natural Regeneration

Planned natural pine regeneration consists of reforesting a stand with existing trees, either through even-aged management by leaving a few seedtrees or leaving groups of trees (shelterwood), or through uneven-aged management by harvesting trees selectively.

For many NIPF landowners and some industrial owners, planned natural regeneration has many financial and nonmarket benefits. For example, advantages of uneven-aged management include (1) generally lower establishment costs, (2) less required labor and heavy equipment, which contributes to lower initial costs and minimizes damage from soil compaction or erosion, (3) enhanced aesthetic appeal to some landowners, and (4) improved wildlife habitat ([23]; see also chapter 3, this volume). Disadvantages include (1) too many seedlings produced per unit area, resulting in the need for expensive precommercial thinning, (2) too few or irregularly distributed seedlings, resulting in underutilized sites and thus forgone returns, (3) costly hardwood-competition control, (4) usually lower volume yields, and (5) inability to use new species or genetically superior stock.

All these advantages and disadvantages are economic in some sense. Minimizing current establishment costs is a prevalent goal of most landowners. For planned natural regeneration, the principal establishment costs likely to be incurred are some means of scarifying the site (e.g., prescribed burning or disking) and controlling competing hardwoods (e.g., via aerial or ground application of herbicides). As the data in Table 2.2 indicate, these costs are considerably less than those for intensive site preparation and planting. Nonindustrial owners seem to desire minimizing establishment costs more than do industrial owners, and are usually more willing to forgo future returns if they can minimize current costs. But a few large land owning forest-products firms do practice natural regeneration on a continuing basis, and they have done quite well financially.

These economic benefits of natural regeneration are offset by some costs. Most importantly, establishing a well-stocked stand of naturally regenerated pine seedlings is difficult and risky. Few landowners have the skills necessary to regenerate stands well without forestry advice. Indeed, even many new forestry school graduates feel uncomfortable with natural regeneration methods, which are more of an art than a science. Foresters with more experience may be more adept at successful natural-stand management.

The economic problems resulting from understocking or overstocking are obvious. Understocked stands will yield less volume than fully stocked stands, thus generating less future income. Yet overstocked stands will require precommercial thinning, which adds expense. The tradeoffs between too many and too few seedlings depend on the degree of departure from a well-stocked stand. Unfortunately, quantifying this risk and the probability of various yields and returns for any given site is extremely difficult. It is this riskiness that is probably the greatest disadvantage of natural regeneration.

Successful natural regeneration will probably require intensive chemical control of competing hardwood vegetation. If hardwoods are not controlled, they will occupy space and utilize nutrients and moisture on the site, significantly decreasing yields of the more commercially valuable pines. Even if hardwoods are reasonably well controlled, owners must still rely on native stock to regenerate the stand. Improved stock selected from fast-growing or disease-resistant trees cannot be used, again tending to reduce yields and future returns.

Another cost of natural regeneration is the opportunity cost of not currently harvesting the seedtrees or shelterwood trees already of commercial size. This delays income from their harvest to the future, lowering their discounted present value. Unless the annual growth rate of the residual trees exceeds the annual discount rate, which is unlikely for mature timber, landowners will make less immediate profit. Additionally, having fewer trees and, therefore, less volume to harvest when the seedtrees are removed in subsequent years is apt to increase their harvest costs, decreasing the price per unit compared to that of cutting all the timber at one time.

Overall, the advantages of lower establishment costs must be weighed against the costs of risk and probability of lower yields than from planted stands. For many owners with little cash on hand, the benefit of lower establishment costs will be the determining factor, regardless of the returns. For owners wanting a less risky investment with a greater probability of specific timber yields and returns, artificial regeneration will be more attractive — it is the preferred alternative of industrial forest-products firms, which rely on wood for mill furnish and for generating cash-flow. Perhaps new NIPF owners who hold forest land principally for investment purposes may also prefer the more guaranteed returns from artificial regeneration to the more speculative returns from natural regeneration.

2.4.3 Direct Seeding

The advantages and disadvantages of natural regeneration apply to direct seeding as well, with a couple of exceptions. Direct seeding may require less intensive and less costly site preparation than does planting. Certainly, the costs of direct seeding itself are less than those of planting seedlings. Direct seeding has two advantages compared with natural regeneration. First, there is no forgone opportunity cost for leaving seedtrees or diminished value for harvesting those trees. Second, direct seeding, if successful, will establish a more uniformly stocked stand than natural regeneration, facilitating future management at the expense of somewhat greater establishment costs.

The principal disadvantage of direct seeding, compared to natural regeneration, is that it is often unsuccessful. It requires favorable weather conditions in the year the seed is spread; otherwise, germination may be poor, requiring the site to be reseeded at added expense. With natural regeneration, the seedtrees will still be there for several years if the seeds do not germinate and grow into seedlings in a particular year. Many unforeseen events, such as droughts, floods, wildlife eating the seed, or excessive brush may cause poor stand establishment. Additionally, even if the stand is successfully regenerated, stocking is hard to predict; it will not be as uniform over the site as with planted seedlings. Although the space on the site may be well utilized in early years, any subsequent thinning or other improvements will be more difficult than they would be with plantations. These costs, coupled with the still greater risk of failure, have led most landowners to choose either planned natural regeneration or planting seedlings instead of direct seeding.

2.4.4 Planting

Planting of southern pines has several advantages. First, except in very dry seasons, planting usually is the most successful regeneration method for establishing a well-distributed, well-stocked stand. Second, because of the better stocking control, returns are usually more assured because product yields, and thus price per unit area, may be estimated more accurately. Third, for forest products firms who rely heavily on their fee lands for mill furnish, plantations are obviously more reliable than natural stands. Plantations are also easier to establish, maintain, manage, regulate, and harvest than are natural stands, allow use of genetically superior planting stock, and are more amenable to decisionmaking in a business environment because of the extensive body of published scientific literature regarding plantation growth, yield, and management.

Returns from southern pine plantations, at least on good sites, are generally quite attractive, despite large initial establishment costs. And usually these returns are realized with very little risk of physical or financial loss, particularly for firms with their own wood-processing facilities. These more assured returns at lesser risks would probably be much more attractive to institutional investors in forestland as well. Natural pine regeneration, if successful, may generate much greater returns for the lower establishment costs made than will plantations. However, the possibility of small returns — for example, because the site does not seed in well or because hardwood competition becomes excessive — is probably greater than that of large returns. Most firms and institutional investors who have adequate capital to invest in growing timber prefer slightly lower, but considerably safer, returns.

Plantations offer many management advantages. Planting and growing seedlings is a well-developed science, supported by extensive public and private research. If landowner objectives are known, the appropriate site-preparation techniques, seedling spacing requirements, and brush-control methods can all be determined from practical experience and existing literature. The yields from plantations are generally quite good and for both thinned and unthinned plantations are generally well quantified, again on the basis of both experience and literature. Plantation management also facilitates forest regulation and harvest scheduling. Both thinnings and final harvests in plantations are considerably easier and cheaper due to the rows and even spacing. Lastly, for mills that want to ensure a stable wood flow over time, the relatively uniform plantation yields are much more desirable.

The high cost of establishment usually associated with planting is its principal drawback. NIPF landowners, in particular, are commonly believed to be reluctant to plant trees because of the large initial costs. Some believe that pine stands will probably regenerate acceptably of their own accord; others simply do not want to spend the capital required. Tax considerations also mitigate against planting pines because of the large initial cost that must be capitalized.

Pines generally only grow well on lands with high site indexes, as would be expected. Plantation establishment costs, however, are fairly similar for both good and poor sites. For example, mechanical site preparation costs about the same on most sites unless an exceptional amount of brush is present; therefore, the net returns may be fairly acceptable on good sites, but only mediocre on poor sites. Thus, any analysis of planting pines should carefully incorporate individual site differences in yields because they are crucial in determining returns and profitability. Likewise, the location of individual tracts with respect to major markets or within a firm's land base would also influence regeneration costs and returns.

The problems of high initial establishment costs for plantations may be ameliorated somewhat. It may be possible for forestry firms, NIPF landowners, or public agencies to require greater utilization at harvesting time, even at the expense of a slightly reduced stumpage rate. The greater utilization should in turn require less intensive site preparation, reducing establishment costs and improving before- and after-tax cash-flows. Landowners should try to minimize the intensity and costs of site preparation methods as much as possible anyway because such an effort is likely to help lower initial investment and improve discounted NPV.

2.5 Planned-Regeneration Decisions

2.5.1 Objectives

As discussed before, forest management and regeneration objectives vary widely among landowners. Most often, these objectives center on (1) timber production (pulpwood and sawtimber), (2) wildlife, (3) aesthetics, (4) flexibility, and (5) costs and returns. Depending on the objective, some regeneration methods may be better than others. Landowner satisfaction with regeneration increases when the objectives are considered before timber harvest. For instance, if aesthetics are of major concern, then seedtree harvesting and natural regeneration may be the preferred option. However, if timber production and maximized profits are of greatest interest, then stands should probably be regenerated artificially either by planting seedlings or direct seeding; standing timber should be clearcut, with as much removed from the site as possible to minimize the need for costly, intensive site preparation at planting time.

2.5.2 Recordkeeping

Because federal and state tax laws require that all expenses involved with regeneration be capitalized, records must be maintained to document expenditures. Receipts, contractors' invoices, and cancelled checks must be retained as evidence of expenses for the life of the stand. A diary or log should be kept of all visits to the site, expenses incurred, and revenues received; these will be necessary for tax calculations. The log will also help NIPF landowners establishing that they are active forest managers, which will be advantageous for tax purposes.

2.5.3 Management Decisions

Management decisions involve site selection, site preparation, planting stock, and planting density. Obviously, correct biological management decisions will yield good financial returns, and vice versa. These biological considerations are introduced here in relation to their economic implications.

2.5.3.1 Site selection

Site productivity as measured by site index is a primary guide in allocating limited funds to regeneration. For example, "higher" sites have greater productive capacity, as shown below for unthinned loblolly pine plantations in the Piedmont at age 30 (Coile and Schumacher [8]):

Site index	Volume	
	m^3/ha	cords/ac.
$70_{(25)}$	42.4	62.2
$60_{(25)}$	28.7	42.1

The change in site index of 17% resulted in a 48% increase in volume and would, of course, increase financial returns greatly. This example emphasizes the necessity of making the best estimates of site index possible. Site index also affects response to silvicultural treatments, thus establishing limits on the type of regeneration and management regimes that a landowner can afford to apply. These differential yields and treatment responses must be considered in economic analyses.

2.5.3.2 Site preparation

The objective of site preparation is to eliminate competing vegetation at least long enough to allow pine seedlings to become established. The site preparation method selected — whether mechanical treatments such as chopping, disking, or root raking, chemical treatments such as herbicide spraying, or prescribed burning — depends on the density of competing vegetation on the site following harvest and on whether seedlings will be machine or hand planted (see chapters 12, 13, and 17, this volume). The expense of site preparation is often considerable, particularly with mechanical treatments. Applying herbicides is usually least expensive; however, environmental protection may limit their use. Mechanical treatments are perceived by some as less risky environmentally but may not provide the degree of hardwood control that herbicides do. The costs of competition control must be compared with the additional timber yields anticipated due to their use to determine if control measures are worth performing.

2.5.3.3 Planting stock

The principal economic concerns regarding planting stock (discussed in detail in chapters 6, 7, and 8, this volume) are seedling quality and cost. The seed source — whether genetically unimproved or improved and, if the latter, at what level — is critical. The yield increase expected from using more costly improved seedlings also must be projected. The incremental cost of using improved seedlings can be compared with the discounted value of any *additional* yield improvements attributable to their use. Quality in terms of survival potential and disease or pest resistance should be quantified, and immediate costs compared to discounted returns on future yields. The economic criteria for determining whether to use improved seedlings remain the same: to pay more for higher quality seedlings, the discounted NPV must be positive, the IRR greater than the discount rate, or the B:C ratio > 1.

2.5.3.4 Planting density

Initial planting density has a modest effect on final volume (see chapter 15) for most longer rotations. As an example, Coile and Schumacher [8] show that a "high" site with 400 trees/ac. (1,000 trees/ha) at age 5 will yield 53.9 cords/ac. at age 30 with no intermediate thinnings; the same site with 800 trees/ac. (2,000 trees/ha) will yield 68.7 cords/ac.. The increase of 27.5% came on 100% more trees and a decrease in average dbh of 11.4%.

Planting density should be such that trees fully occupy the site by age 15 without limiting stem size. Periodic thinnings will help keep the stand vigorous; 650 to 700 trees/ac. (1,600 to 1,730 trees/ha) is a common planting-density target in the South. To be able to evaluate the economics of initial stocking, managers must be able to quantify yields as a function of (1) varying densities, (2) thinning regimes, (3) rotation age, (4) protection costs, (5) survival rates, and (6) harvesting costs.

2.5.3.5 Interplanting versus replanting

The decision to interplant, or to plow under and start over, is difficult (see chapter 18, this volume). The cost of plowing under is quite substantial — equivalent to that of a plantation failure. The only time that it pays to start over is when the stand has been left so poorly stocked that the volume of the residual trees does not have a potential present value greater than the cost of replanting. Interplanting may be desirable if done early enough to avoid creating a two-storied stand. Often, however, it is more economical to re-establish or leave the stand alone than to interplant.

2.5.3.6 Regeneration delay and cost control

Regeneration delays have several costs. Delay adds to the length of the rotation, thereby decreasing the potential return on investment. Delay also allows competing vegetation to establish itself, requiring additional capital for site preparation. Successful capital investments require few delays, rapid payoffs, cost control, and quality control. Regeneration delays, poor-quality seedlings, sloppy planting, and slow workers all reduce regeneration returns.

2.6 Example Discounted Cash-flow Calculations

In order to clarify the concepts described in this chapter,

Table 2.6. Example loblolly pine regeneration and management alternatives, site index 65, base age 25. [1] (See text for assumptions.)

Activity	Natural regeneration		Site preparation (SP) and planting			
			High-intensity SP,	Low-intensity SP		
	Unplanned before tax	Seedtree, before tax	before tax	Before tax	After tax	Cost-share/ tax incentives
Costs						
Property tax (rotation age)	3(0–44)	3(0–44)	3(0–24)	3(0–30)	3(0–30)	3(0–30)
Administration	–	2(0–44)	2(0–27)	2(0–30)	2(0–30)	2(0–30)
Burn site for planting	–	3.29(0)	–	3.29(0)	3.29(0)	3.29(0)
Burn piles	–	–	(5.86)(0)	–	–	–
Disk	–	60.22(0)	–	–	–	–
Chop	–	–	–	52.96(0)	52.96(0)	52.96(0)
Shear, rake, and pile	–	–	125.81(0)	–	–	–
Inject herbicides	–	40.11(0)	–	–	–	–
Seedlings	–	–	25.00(0)	15.00(0)	15.00(0)	15.00(0)
Prescribed burn	–	3.29 (11,18,25,32)	3.29 (7,14,21)	3.29 (8,15,22)	3.29 (8,15,22)	3.29 (8,15,22)
Hand plant	–	–	–	38.78(0)	38.78(0)	38.78(0)
Machine plant	–	–	30.35(0)	–	–	–
Mark timber	–	8.26(21)	10.64(16)	10.64(18)	10.64(18)	10.64(18)
Mark timber	–	9.03(30)	–	–	–	–
Mark timber	–	25.31(40)	–	–	–	–
Pay income taxes:						
Thinning	–	–	–	–	49.75(18)	49.75(18)
Final cut, pulpwood	–	–	–	–	73.73(30)	73.73(30)
Final cut, sawtimber	–	–	–	–	199.73(30)	199.73(30)
Seedtrees	–	–	–	–	–	–
Returns						
Stumpage sales						
Thin pine						
Pulpwood	–	161.92(21)	250(16)	225(18)	225(18)	225(18)
Chip and saw	–	243.20(30)	–	–	–	–
Sawtimber	–	228.97(30)	–	–	–	–
Final cut pine						
Chip and saw (pulp)	75(44)	246.24(40)	350(27)	300(30)	300(30)	300(30)
Sawtimber	300(44)	2393.59(40)	900(27)	750(30)	750(30)	750(30)
Seedtree cut, pine sawtimber	–	537.92(44)	–	–	–	–
Final cut, hardwood						
Pulpwood	50(44)	–	–	–	–	–
Sawtimber	75(44)	–	–	–	–	–
Cost-share payment	–	–	–	–	–	55.01(0)
Tax credit (1/2)	–	–	–	–	–	5.50(0)
Tax deduction (1/2)	–	–	–	–	–	0.98(0.8)
Tax deduction (1/2)	–	–	–	–	–	1.96(1–7)

[1] Costs from Watson et al. [39]; estimates of yields adapted from Bailey et al. [1] for plantations, Brender and Clutter [4] for natural stands; stumpage values adapted from Neal and Norris [29].
[2] Dollars per acre may be converted to dollars per hectare by multiplying values by 2.4710.

several examples were developed to demonstrate how discounted cash-flow analyses are performed for a variety of typical southern pine regeneration alternatives.

2.6.1 Regeneration Alternatives

The costs and returns for example regeneration alternatives are summarized in Table 2.6. The 1986 input costs for each management regime were taken from South-wide averages reported by Watson et al. [39]. Estimates of yields were adapted from Bailey et al. [1] for plantations and from Brender and Clutter [4] for natural stands. Stumpage values were adapted from Neal and Norris [29]. In practice, these may differ significantly from the examples shown, which would lead to significantly different returns.

The unplanned natural regeneration regime represents the possible costs and returns for a "cut and get out" strategy — in which hardwoods will constitute most of the next crop. The seedtree regeneration method has already been described (section 2.4.2). The high-intensity site preparation and planting regime might typify industrial forestry practices, including use of more expensive, genetically superior seedlings. The low-intensity site

Table 2.7. Results from example regeneration and management alternatives (see Table 2.6), 4% before-tax real discount rate.

	Natural regeneration		Site preparation (SP) and planting			
				Low-intensity SP		
Investment criterion	Unplanned, before tax	Seedtree, before tax	High-intensity SP, before tax	before tax	after tax	Cost-share/ tax incentives
Net present value, $/ac.[1]	53.72	739.94	378.01	302.82	320.21	393.16
Land expectation value, $/ac.	65.35	894.06	578.72	437.80	558.48	685.72
Equivalent annual income, $/ac.	2.61	36.01	23.15	17.51	16.08	19.75
Real internal rate of return, %	6.17	10.21	8.23	8.27	7.12	9.73
Benefit : cost ratio	1.83:1	7.05:1	2.33:1	2.43:1	1.86:1	2.05:1

[1] Dollars per acre may be converted to dollars per hectare by multiplying values by 2.4710; percentage returns and benefit : cost ratios remain the same regardless of unit measurement.

preparation and planting regime might typify that of an NIPF owner who has made a modest initial investment and has used inexpensive state planting stock. The first after-tax analysis in the low-intensity site preparation case would be for an NIPF owner in the 28% tax bracket who is considered active in the trade or business; all establishment costs were assumed to be capitalized until the end of the rotation. The second after-tax analysis would be for a similar NIPF owner who also received cost-share payments and used reforestation tax incentives; cost-share payments were assumed to be excluded from income, so only half the value of the tax credits and deductions were included in the cash-flow analysis.

2.6.2 Example Results

For the hypothetical regime shown in Table 2.6, the seedtree regeneration alternative is clearly the most profitable (Table 2.7): it has the highest NPV, LEV, IRR, and B:C ratio. This result is somewhat surprising because analysts usually think of plantation investments as having greater returns. However, when the seedtree method results in a fully stocked stand, it can be quite successful. Also, the yield tables used for the seedtree method [4] indicated that it would produce more volume than the yield-table values indicated for plantations [1]. In reality, this result seems unlikely. Chances of failure or of a thinly stocked stand are greater with seedtree regeneration than plantations. The risk of possible smaller yields should be evaluated by sensitivity analysis.

The high-intensity site preparation and planting regime generally seems to be the second best alternative for the site, based on NPV and LEV at the stated 4% discount rate. If, however, the discount rate increased, the comparative desirability of high-intensity site preparation would probably decrease, and would be negative at real discount rates > 8.23%.

The low-intensity site preparation and planting regime without government assistance was only moderately better than unplanned natural regeneration. If this result were frequently true in practice, it might help explain why NIPF landowners often do not make active attempts to artificially regenerate southern pines. The low-intensity site preparation alternative also illustrates the importance of income-tax payments and of cost-share payments and tax credits in determining regeneration returns. The before-tax real discount rate was 4%; this translated into a 2.88% after-tax real rate at the assumed 28% income-tax bracket. On the basis of this lower discount rate, the after-tax NPV of the investment was still greater than the before-tax value at 4%. Additionally, the LEV was even greater because future incomes would be worth more in present dollars at a 2.88% rate than at a 4% rate. IRR after taxes was less than before taxes, however, as one would expect, as was the B:C ratio. These anomalies in comparative project rankings help illustrate why LEV and NPV are preferred criteria for regeneration alternatives.

The returns for the low-intensity site preparation and planting regime with cost-sharing and tax incentives were significantly better than those without the assistance of public programs. The payments, credits, and deductions increased all the measures of financial performance.

These hypothetical returns are valuable principally for illustration. The comparisons among different regeneration methods may produce vastly different physical and financial results depending on the site, inputs, costs, and yields. Each analyst should obtain the best available estimates for these factors and perform the discounted cash-flow analyses accordingly.

2.7 Conclusions

This chapter has presented an analytical framework for performing an economic evaluation of southern pine regeneration alternatives. The basics of economic analyses were presented, data sources described, and applications illustrated, including the effects of public tax and incentive policies.

In applying these concepts, several steps should be followed. First, forest landowner objectives should be determined. Next, the regeneration alternatives and management regimes that could meet these objectives should be delineated. Then, the quantity, timing, and prices of the regeneration inputs and outputs, which form the basis for a discounted cash-flow analysis of each alternative, must be estimated. All the relevant capital budgeting criteria, summarized in Table 2.5, can be used to help select among the alternatives. The management regime with the greatest expected return would normally be recommended as the best means of regeneration. This may, however, not account well for the risk of failing to establish a satisfactory stand, which should also be taken into consideration through sensitivity analyses or using one's judgment.

Financial analyses should be performed on a before-tax basis in every case, and on an after-tax basis if the landowner or analyst deems this relevant. All costs and prices should be estimated consistently in either nominal (current dollars, including inflation) or real (constant dollars, not including inflation) terms. We generally recommend using real prices and real discount rates for comparing alternative regeneration investments because they are less likely to lead to confusion. Price increases greater or lesser than the rate of inflation, however, should be taken into consideration in the cash-flows by making the appropriate changes in real prices.

The effects of public subsidies for timber growing should also be included in the cash-flows at the time they occur. Cost-share payments are income at the time of establishment, as are tax credits. Tax deductions such as reforestation amortization, tax effects of management expenses and timber stand maintenance, and direct payments such as received under the Conservation Reserve Program, are considered revenues in the year they occur.

Any enhancements or returns that result from biological inputs or management techniques must be quantified and entered into the cash-flows. For example, genetically improved seedlings should increase yields, and an accurate estimate of these increases, as well as the added costs of using genetically superior stock, must be included. Similarly, improved control of competing vegetation also should increase yields, but again at some cost. These input and output relationships and costs can be obtained from published literature, or company or agency records, or even as best guesses from knowledgeable foresters.

Economic calculations may be made by hand or via public domain or commercial software. Analysts with public agencies and private firms typically use discounted cash-flow software packages. A large amount of microcomputer software, such as Quicksilver [38] and CASH [2], which was used for this chapter's examples, is available for cash-flow analyses. Moreover, the format of the cash-flow table lends itself to spreadsheet software.

In conclusion, this chapter explains the basic economic methods needed to analyze regeneration or indeed other forestry decisions. Foresters and other analysts can use the detailed biological information contained in subsequent chapters in this volume to estimate the physical input and output relationships for regeneration and management of southern pine. They can then consider landowner's objectives, relevant prices, and economic criteria to help decide which biological alternatives are preferable.

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