CULTURAL PRACTICES IN APPALACHIAN HARDWOOD SAPLING STANDS--ARE THEY WORTHWHILE?

Gary W. Miller

Economist
USDA Forest Service
Northeastern Forest Experiment Station
Parsons, WV 26287

ABSTRACT

Forest managers often question the economic feasibility of cultural practices in hardwood sapling stands. Investment factors, including initial treatment cost, required rate of return, investment period, and stand response to treatment are discussed in terms of how they affect the outcome of early investments in even-aged hardwood stands. Attention is focused on precommercial thinning in hardwood sapling stands. Guidelines are provided to indicate the maximum allowable treatment cost under which precommercial thinning can be profitable. Data suggest that precommercial thinning is economical only in young stands containing relatively high-value species.

Introduction

Forest managers often question the need for cultural practices in hardwood sapling stands.

1. What can be gained by applying cultural treatments in young stands?

2. What is the rate of return on early precommercial cultural treatments?

3 Are cultural treatments in hardwood sapling stands economical?

Unfortunately, there are no universal answers to these important questions. A precommercial treatment in young hardwood stands is essentially a direct investment in timber production, and the profitability of that investment depends on many factors. These factors include initial treatment cost, required rate of return, investment period, and stand response to treatment. This paper provides basic information on each of the four investment factors. Guidelines are provided to assist forest managers in evaluating precommercial thinnings in hardwood stands. The guidelines indicate the maximum allowable treatment cost under which precommercial thinning can be profitable--they indicate when early investments in thinning earn just as much money as other similar investments available to the landowner.

Initial Treatment Cost

Cultural practices in very young hardwood stands rarely yield merchantable products. Stems cut during weedings, cleanings, and crop-tree release are usually unmerchantable due to small average size and the high cost of removing, transporting, and processing the material. In herbicide treatments, unwanted stems are left standing in the woods. Thus, for most treatments in sapling stands, there is no immediate income to offset some of the treatment cost.

Regardless of the name given to a particular precommercial cultural practice, the effect on the landowner's pocket book is the same--the treatment costs money and the money spent should be viewed as an investment in an immature timber stand. Most precommercial cultural practices are timber stand improvement (TSI) operations such as removing undesirable trees or species and vines. Also included are precommercial thinnings to control stand density and redistribute growth to desirable residual stems. The goal in each of these practices is to provide the landowner with higher stumpage revenues in the future as a direct result of the early investment.

To determine the economic feasibility of a proposed cultural practice in a given stand, the forest manager first needs to know the total cost of the treatment. This provides a basis for determining the residual stand response needed in the future to recover the initial investment. In addition to the actual cost of carrying out the operation, the landowner must consider the cost of professional services directly related to the treatment. These services may include evaluating the initial condition of the stand and/or marking trees in the stand. When cost sharing is available, the total cost to the landowner will be reduced. The total cost to the landowner should include all expenditures related to the treatment minus any immediate income or cost-sharing that reduce the landowner's out-of-pocket expenses.

The total cost of a particular cultural practice will vary depending on the initial condition of the stand and the method employed to complete the operation. For example, vine control in immature stands can cost from $5 to $50/acre, depending on the severity of the vine problem and the method used to eliminate the vines (Smith 1984). Table 1 shows the possible range in total treatment cost for selected precommercial cultural practices. Those figures were derived from recent cost studies which provided treatment cost indicators such as man-hours; machine hours, chemical usage rates, and fuel requirements (Miller 1984a, b). Ranges are presented to illustrate the variability of investments in young hardwood stands. For some precommercial practices, the ranges are relatively narrow. A crop tree release treatment in a 15- to 20-year-old stand, for example, could cost from $28 to $45/acre using chain saw felling as the treatment method.

However, a chemical release in the same stand could cost from $38 to $75/acre.

Table 1. Treatment costs per acre for selected precommercial cultural practices.

Treatment	Method	Cost/acre
		Dollars
Crop-tree release	Chain saw felling	28-45
Crop-tree release	Stem injection	38-60
Crop-tree release	Basal spraying	47-75
Vine control	Cutting	5-50

Required Rate of Return

A precommercial cultural treatment in a young hardwood stand is only one of many investment opportunities available to a woodland owner. For example, the landowner could sell the woodland and invest the proceeds in stocks or bonds. However, for most landowners considering precommercial thinning in a young stand, the decision to continue producing hardwood timber has already been made. Thus, the landowner has to decide between two courses of action--invest in a precommercial thinning or allow the young stand to grow undisturbed.

To evaluate a proposed investment in a hardwood sapling stand, the forest owner or manager must identify the "required rate of return." The required rate of return can be determined by the source of the money used to pay for the stand treatment. If the landowner withdraws money from savings to pay for the treatment, the thinning should provide a return at least equal to the interest earned in the savings account. If the landowner takes out a loan to finance the treatment, the thinning should provide a return at least equal to the interest paid on the loan. To be economical, a long-term forestry investment is "required" to earn at least this rate of return. Otherwise, the landowner is losing money by investing in a precommercial thinning.

For most landowners, I recommend using 9 or 10% as the required rate of return. Sometimes, nonmonetary returns such as the development of wildlife habitat may justify a lower rate. The landowner may feel that a 7.5% return is satisfactory considering other management objectives. But from a strict economic standpoint, the required rate of return on precommercial cultural practices should be determined by the individual landowner's sources of funding.

Real rates vs market rates of return

Market rates are easy to understand because we all deal with them in our personal finances. Interest rates on car loans, mortgages, savings accounts, and money markets are all market rates. A real rate of return simply indicates how much an investment will earn without the effects of inflation (Foster 1984). This is useful in analyzing long-term forestry investments because with real rates of return there is no need to predict how inflation will affect stumpage prices over time. The following formula is used to compute the required <u>real</u> rate of return:

$$+ r = (1 + m)/(1 + i)$$

where

r = decimal equivalent of the real rate
m = decimal equivalent of the market rate
i = decimal equivalent of the inflation rate.

If inflation is expected to be 5%, and the required market rate of return is 9%, then the required real rate of return is about 4%. In other words, a forestry investment that earns a 4% real rate of return is equivalent to one that earns a 9% market rate of return when the annual inflation rate is expected to average 5% in the future.

Real rates of return are useful for computing the future growth and stand value increase needed for a profitable treatment without the effects of inflation. Today's stumpage prices can be used to determine the future volume increases needed to recover the initial investment. This simplifies the analysis and makes it easier to evaluate the treatment in terms of diameter growth, volume growth, and changes in species composition familiar to most foresters.

Though the required rate of return may not be the same for two landowners considering the same investment, the analytical procedure for evaluating a precommercial culture practice is essentially the same. The forest owner or manager must first determine the total cost of the investment and then determine the required rate of return on money invested in the stand. Once these two investment factors are defined, the analysis focuses on predicting the residual stand response and the potential for increasing net stumpage revenues in the future. The success of the investment will depend on the amount of stand value increase and the length of time the landowner must wait for the added value.

The Investment Period

The objective of a precommercial cultural practice is to increase the landowner's net income from the stand at some time in the future. As with all investments, the landowner must wait a given period of time for the returns on the investment. The length of time the landowner must wait for the added income is called the "investment period."

Together with the cost of the proposed cultural practice and the landowner's required rate of return, the investment period determines how much stand value increase is needed for an economical investment.

Precommercial cultural practices entail relatively long investment periods, from about 20 to 70 years depending on the initial age of the treated stand. For a given treatment cost and required rate of return, the longer the investment period, the greater the return must be to result in an economical investment. But estimating the exact length of investment period can be difficult. Thus, the length of the investment period depends on the owner's expectations about the growth response of the treated stand and the size of merchantable produces in local markets.

Because these factors are extremely variable among individual timber stands, it is wise to evaluate a particular cultural treatment using a range of investment periods. Using a range of investment periods simply provides more information for evaluating the proposed investment. For example, I would bracket the proposed investment period with two more investment periods--one 10 to 15 years shorter and one 10 to 15 years longer. This provides the landowner with an idea of future income in the event that harvests must be made sooner or later than originally planned. This also provides a clear picture of how the outcome of the proposed investment will be affected by the estimated growth response and the time required for future crop trees to reach merchantable size classes.

Stand Response to Treatment

Most young hardwood stands increase in value over time without help from a well-meaning forest manager. Simply, as the trees get larger, they are worth more money. The trick is to get the higher quality, more valuable species to be the larger trees. By favoring the most valuable trees in the stand through an early cultural treatment, the landowner expects to increase the revenues from future harvests. Because an early cultural treatment requires a cash investment that must be held for a relatively long period of time, the increase in future harvest revenues must be large enough to earn the landowner's required rate of return. Thus, the initial treatment cost, the investment period, and the required rate of return can be used to compute the return needed for an economical investment.

The dollar return needed for an economical investment is the difference between the future value of the treated stand and the future value of the untreated stand. In other words, it is the stand value increase that occurs as a direct result of the treatment. Once the needed increase in value has been defined, the forest manager can determine if such an increase in revenues is likely.

The dollar return needed to earn the required rate of return on the initial investment is computed by the formula:

$$FV = PV\ (1 + r)^n$$

where PV = initial investment in dollars (present value)

r = required real rate of return expressed as a decimal

n = investment period in years

FV = needed stand value increase in dollars (future value).

In Table 2, the stand value increase needed to earn a 4% real rate of return is presented for a range of treatment costs and investment periods. For example, if a proposed cultural treatment costs \$30/acre, and the final harvest will not occur for 40 years, the treated stand must be worth \$144 more per acre than the untreated stand at the final harvest, assuming no other intermediate cuttings are made.

Table 2. Stand value increase needed to earn a 4 percent real rate of return.

Investment period (years)	Initial treatment cost							
	10	20	30	40	50	60	70	80
	--Dollars/acre--							
10	15	30	44	59	74	89	104	118
15	18	36	54	72	90	108	126	144
20	22	44	66	88	110	131	153	175
25	27	53	80	107	133	160	187	213
30	32	65	97	130	162	195	227	259
35	39	79	118	158	197	237	276	316
40	48	96	144	192	240	288	336	384
45	58	117	175	234	292	350	409	467
50	71	142	213	284	355	426	497	569
55	86	173	259	346	432	519	605	692
60	105	210	316	421	526	631	736	842
65	128	256	384	512	640	768	896	1,024
70	156	311	467	623	779	934	1,090	1,246
75	189	379	568	758	947	1,137	1,326	1,516
80	230	461	691	922	1,152	1,383	1,613	1,844

Potential benefits of precommercial cultural practices

The final step in analyzing a proposed investment in a young stand is to determine the stand value increase that will result from the treatment being considered. Initially, the potential benefits of the treatment can be expressed in physical terms such as increased diameter growth and increased merchantable volume at final harvest. To complete the analysis, however, the benefits must be converted to dollars and compared with the dollar return needed for an economical investment. This step in the analysis requires the forest manager to make certain assumptions about the stand's response to treatment. In some instances, very little information is available to predict the outcome of a cultural treatment. But in most cases, published results of silvicultural studies can be used to make realistic assumptions about growth and value changes in treated stands.

Another way to analyze the proposed treatment is to determine the growth response needed for an economical investment. The future dollar return needed for an economical investment can be converted to board-foot volume or diameter growth using real stumpage prices. Once the needed growth response is defined, the forest manager can determine if such a response is likely based on current growth and yield information.

Figure 1 illustrates how this procedure can be used to evaluate a proposed precommercial thinning in a young hardwood stand. In this example, three graphs are combined into a nomogram (Seymour and Gadzik 1985) to compute the diameter-growth response needed for an economical treatment. Each graph represents a step in the analysis. The first graph (upper right) is used to compute the dollar return needed to earn a 4% real rate of return on the investment. The second graph (upper left) is used to determine the equivalent board-foot volume based on current stumpage prices. The third graph (lower left) is used to determine the increase in average diameter of future crop trees needed for an economical treatment.

To use the nomogram, enter the top of the first graph (Figure 1, upper right) at the appropriate treatment cost and draw a vertical line down to the curve that corresponds to the estimated investment period. In this example, the thinning cost is $30/acre and the estimated investment period is 40 years. At point A, the future dollar return needed to earn a 4% real rate of return, $144/acre is shown at the left. To determine the needed increase in stand volume, move horizontally from point A to the left, stopping at the curve that corresponds to the current stumpage price. In this example, the current stumpage price is $75/thousand board feet (M bf) and it is assumed that there will be no real increase in stumpage prices during the investment period. At point B, the needed increase in volume, about 1.9 M bf/acre, is shown at the bottom. To determine the needed increase in diameter, draw a vertical line from point B down to the curve that corresponds to the projected merchantable height of future

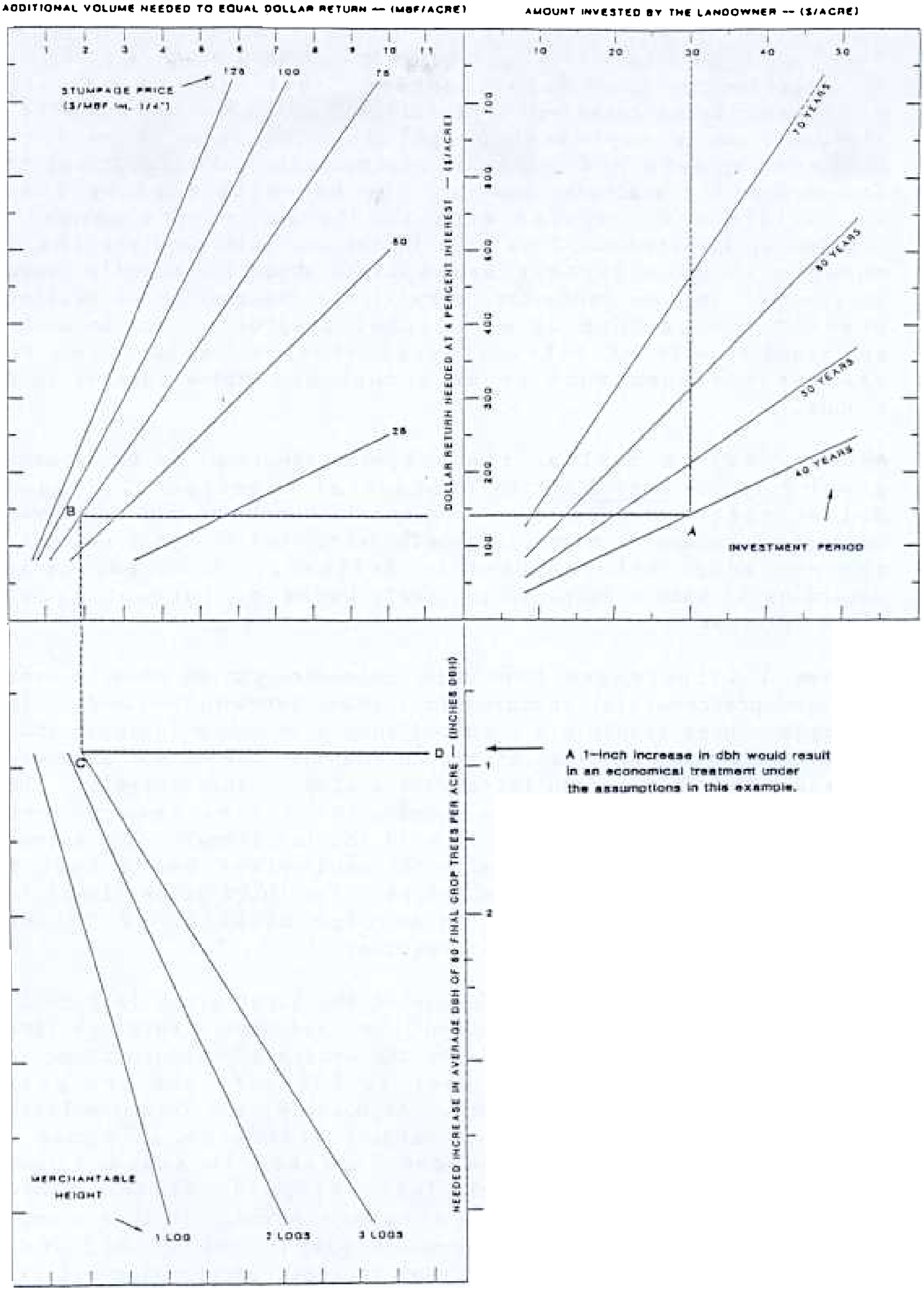

Figure 1. Sample graphical computation of the diameter growth response needed to earn a 4 percent real rate of return from precommercial thinning with an initial cost of $30 per acre.

crop trees. In this example, the projected merchantable height of future crop trees is 3 logs (48 feet). At point C, the needed increase in diameter at breast height (dbh) is shown at the right. Point D indicates that a 1-inch increase in the average diameter of future crop trees would provide the volume increase and dollar return needed for an economical investment.

The third graph (Figure 1, lower left) is based on the assumption that the future stand will contain 60 crop trees/acre that average 16 inches dbh without a precommercial thinning. In the example, precommercial thinning must result in a 1-inch increase in average dbh for an economical treatment. This will increase the merchantable stand volume and provide the additional stumpage revenues needed for a 4 percent real rate of return on the initial amount invested in precommercial thinning. The forest manager considering this treatment must now determine if a 1-inch increase in the average dbh of future crop trees is likely.

Precommercial thinning treatments in Appalachian hardwood sapling stands <10 years old have not resulted in significant increases in individual-tree diameter growth (Smith 1979; Beck 1977; Trimble 1973; Hilt and Dale 1982). In 10- to 20-year-old stands, however, diameter growth increased as a result of crop-tree release and other precommercial thinning techniques (Della-Bianca 1975; Church 1955; Smith and Lamson 1983; Stoeckeler and Arbogast 1947). While the diameter growth of selected trees can be increased by early cultural treatments, evidence suggests that the response is short-lived. Thinned trees grow significantly faster than unthinned trees for a maximum of 10 years. After 10 years, crop trees in the thinned stand are larger than trees in the unthinned stand, but the future growth of trees in both stands is about the same. Thus, the major benefit of an early thinning is a slight increase in the average diameter of future crop trees. On the basis of current information, the average diameter of selected crop trees can be increased by a maximum of 1.0 to 1.5 inches by crop-tree release. This means that at any point in time beyond the initial treatment period (10 years), released trees will be 1.0 to 1.5 inches larger than their unreleased counterparts.

What does this mean in terms of stand value added by the treatment? Since tree volume is a function of dbh, the growth response of released crop trees can be converted to board-foot volume and value. A 1-inch difference in dbh results in a difference of about 35 board feet (International 1/4-inch rule)/tree for trees 16 inches dbh with a merchantable height of 3 logs. In a stand with approximately 60 crop trees/acre, the early cultural treatment could add about 2,000 board feet/acre at the final harvest. Assuming a stumpage price of $75/M bf, the treatment could increase future harvest revenues by $150/acre. So, it appears that the precommercial thinning in this example can provide the landowner with a 4% real rate of return. The needed growth response is not beyond the capability of a young hardwood stand.

The benefits associated with other types of precommercial cultural practices are more difficult to quantify. Controlling grapevines in a sapling stand reduces the number of trees with broken crowns later in the life of the stand. The benefits associated with investments in grapevine control are actually a reduction in the number of lost crop trees or a reduction in lost growth on trees that survive but grow slowly due to the presence of vines. To evaluate the investment, the forest manager must estimate the total dollar value of losses reduced by early vine control. In a stand with a severe vine problem, the reduction in losses may be substantial, but the cost to treat a severe vine problem is also substantial. Conversely, a stand with few vines/acre will not require a large investment to control the vines, but the reduction in future losses resulting from the treatment will also be small.

Thus, it is extremely helpful to know what must be gained in the future to recover an investment today. By quantifying the future return needed to recover the initial investment, the forest manager knows how much he or she can afford to put into vine control. If the needed gain is beyond the biological capability of the stand, the forest manager can avoid the proposed investment and earn a higher return in an alternative investment.

Economic guidelines

Precommercial thinning is the most common cultural practice considered in young Appalachian hardwood stands. The objective in precommercial thinning is to increase the future stand value by favoring the most desirable trees in the stand. The landowner hopes to increase future harvest revenues by investing money in the young stand. Most cultural practices in hardwood sapling stands should be evaluated using a 4% real rate of return. This is equivalent to a market rate of 9 or 10% if inflation averages 5 or 6% in the future. To assist forest managers in evaluating cultural practices in young hardwood stands, economic guidelines were developed for precommercial thinning. The guidelines indicate the range of circumstances under which these treatments will earn a 4% real rate of return.

Current silvicultural information indicates that precommercial thinning can increase the dbh of future crop trees by about 1.0 to 1.5 inches. Because the potential gain in tree diameter is limited, the potential increase in merchantable volume and stand value is also limited. Assuming a hardwood stand at final harvest contains 60 crop trees/acre averaging 16 inches dbh, the maximum gain in stand volume from a 1-inch increase in dbh is about 2,000 board feet (International 1/4-inch)/acre. The maximum gain in stand value depends on the real stumpage price of future crop trees. In Table 3, the maximum gain in the stand value is shown for stumpage prices ranging from $50 to $150/M bf. If the stumpage price is $50/M bf, the maximum gain in stand value is only $100/acre. If the stumpage price is $125/M bf, the maximum gain in stand value is $250/acre. Figures in Table 3 do not include the effects of inflation. As a result, current stumpage prices can be used to estimate the maximum potential gain in stand value.

Table 3. Maximum allowable precommercial thinning cost for a 4 percent real rate of return--based on a projected 1-inch increase in dbh of future crop trees[a].

Current stumpage price of future crop trees (Dollars/M bf)	Maximum gain in stand volume[b]	Maximum gain in stand value	Maximum allowable precommercial thinning cost by investment period			
			Years			
			20	30	40	50
	M bf/acre		----Dollars/acre---			
50	2.0	100	46	31	21	14
75	2.0	150	68	46	31	21
100	2.0	200	91	62	42	28
125	2.0	250	114	77	52	35
150	2.0	300	137	92	62	42

[a]Future stand without precommercial thinning contains 60 crop trees/acre averaging 16 inches in dbh.
[b]International 1/4-inch rule.
[c]Assumes that the average dbh of future crop trees will increase 1 inch as a result of the thinning.

A useful guideline for forest managers contemplating a precommercial thinning is the maximum allowable treatment cost/acre. How much can I afford to spend on crop-tree release? In Table 3, the maximum allowable treatment cost is provided for a range of stumpage prices and investment periods. For example, a forest manager is considering crop-tree release in a 20-year-old stand containing mostly black cherry. The current local stumpage price for black cherry is $100/M bf. If the investment period (years until final harvest) is 40 years, the forest manager can afford to spend $42/acre for crop-tree release. However, if the investment period is 50 years, the maximum treatment cost is only $28/acre.

Discussion

Precommercial thinning in young Appalachian hardwood stands can be a worthwhile investment for some landowners. For others, it is simply a losing proposition. To evaluate a proposed cultural treatment in a young stand, it is important to consider each investment factor and how it relates to a particular stand and to the landowner's objectives and financial resources.

The potential for economical precommercial cultural treatments is greatest in stands containing relatively high-value species. Research has shown that increases in dbh growth following precommercial thinning are limited and short-lived. Thus, for a given growth response, the total increase in stand value depends on the future value of crop trees at final harvest. In addition to increasing diameter growth, precommercial crop-tree release can be used to influence species composition. Although species composition cannot be altered dramatically in 15- to 20-year-old stands, early release can improve species composition at final harvest and bring about some increase in future harvest revenues. This is in addition to increased revenues that result from faster diameter growth. Improvements in tree quality and log grade resulting from precommercial thinning can further increase future harvest revenues.

There are three ways landowner income can be increased by precommercial thinning--increased diameter growth, improved species composition, and improved tree quality. In this report, I focused on potential increases in tree size and stand volume in evaluating the economics of precommercial thinning. In a more comprehensive paper I will analyze the economic effects of changes in species composition and tree quality resulting from precommercial cultural practices. This report will include additional nomograms like Figure 1 for various rates of return, treatment costs, and investment periods. Field foresters will find these useful in dealing with individual landowners.

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Parsons, West Virginia 26287

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