CHAPTER 7: THE FOREST VALUE – LAND AND TREES

The *Land Expectation Value* (LEV) gives the present value of the costs and revenues from an infinite series of identical even-aged forest rotations, starting from bare forest land – i.e., land that is just ready to begin growing a new crop of trees. But what about the value of a tract of forest that is already established? How is the value of a piece of property with an existing stand of trees determined? Questions like these can be answered with a generalization of the LEV called the *Forest Value*.[1] The Forest Value gives the value of a forest property at any point in the rotation, based on the present value of the expected costs and revenues from the remainder of the current rotation, plus the present value of all the future rotations of timber that will be grown on the property. In addition to applying to even-aged stands, the Forest Value also applies to uneven-aged properties.

The Forest Value relaxes some of the more restrictive assumptions of the LEV and applies to a much broader set of conditions. The LEV applies only to bare land, and a relatively small proportion of forest lands are bare at any given time. The Forest Value can be used to calculate the value of a property that is at any stage of its development, with or without an existing stand of trees. As with the LEV, the Forest Value is useful for both valuing forested properties and for analyzing management decisions. It is particularly useful for determining whether an existing stand of timber should be harvested or left to grow for an additional period of time. The Forest Value also separates the assumptions about how the current stand will be managed from the assumed management regime for future stands on the site, relaxing the assumption that all rotations must be the same. It will still be necessary to assume that all future rotations will be the same, but the management of the current rotation can be different from the management of future rotations. The part of the Forest Value that accounts for the present value of costs and revenues from future rotations uses a LEV calculation, so all of the assumptions that the LEV makes must apply to all future rotations in the Forest Value calculation. In any case, long-term assumptions such as those that apply to future rotations are less critical than short-term assumptions such as those that apply to the current stand because discounting reduces the significance in the overall analysis of values far in the future.

Because the assumptions for the current stand do not have to be the same as the assumptions for the future stand, the Forest Value also allows for price changes that might occur during the life of the current stand. This, too, is an important relaxation of the restrictive assumptions of the LEV. It is often quite reasonable to assume that real stumpage prices will change over the next five, ten or even 20 years. In many cases, especially where good historical price data are available for analyzing price trends, it is more realistic to assume that prices will change than to assume that

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[1] In this context, the Forest Value is a *generalization* of the LEV because it applies to a broader set of circumstances than the LEV. The LEV is a special case of the Forest Value, as we shall see, that only applies to the case where one is starting from bare land.

they will remain constant. However, because the Forest Value assumes that all future rotations (as opposed to the current rotation) will be the same, it must assume that stumpage prices will reach some long-term steady state after the current stand is harvested.

1. Initial Examples

Rather than diving right into the general definition of the Forest Value it might be helpful to first consider a couple of examples.

Forest Value Example #1

You are planning to purchase a timbered tract that you plan to harvest immediately, with the intention of regenerating the stand for future timber crops. The tract is a northern hardwood stand with 18 mbf of sawtimber and 14 cords of pulpwood per acre. Currently, northern hardwood stumpage prices are about $325/mbf and $7/cord in your area. How much can you afford to pay for this tract?

Answer: The value of this tract equals the sum of the value of the timber and the value of the land. At this point, we have no information about the value of the land. For now, only the timber value can be calculated:

$$\textit{Timber value} = \sum_{p=1}^{2} P_p Y_{p,0} = \$325/mbf \times 18mbf + \$7/cd \times 14cd$$
$$= \$5{,}948$$

This gives the value of the standing timber. The next step is to determine the value of the bare land. If market values for bare forest land are available for the area (from transactions evidence), these would probably the best values to use. However, we will assume here that good transaction evidence is not available and we will assume that the value of the bare land is best estimated by calculating the LEV for all future rotations. To calculate the LEV, some additional information will be needed regarding the management of the future stands that will be grown on the tract.

Example #1 (cont.) – After the stand is harvested, you plan to regenerate it naturally. In 30 years, you expect the new stand will need a timber stand improvement cut. The TSI harvest should yield about 12 cords of hardwood pulpwood. In another 30 years (i.e., at age 60), you expect the stand will be clearcut again, with an expected yield of 13 mbf of sawtimber and 25 cords of pulpwood. Annual taxes on the property are $5 per acre. All of your cost estimates are in 2005 dollars, and you expect real stumpage prices and taxes to remain relatively constant. You want to earn a real rate of return on your investment of at least 5%. It is reasonable to assume that the management regime for all future stands will follow this same management regime.

Answer (cont.) – The LEV can be calculated using *Method 3* from Chapter 6. Ignoring the annual cost, the compounded (future) value of the costs and benefits from each future rotation is:

$$FV'_{R_1} = 12 \times \$7 \times (1.05)^{30} + 13 \times \$325 + 25 \times \$7 = \$4{,}763.04$$

Now, the LEV can be calculated as follows:

$$LEV = \frac{FV'_{R_1}}{(1+r)^R - 1} - \frac{tax}{r} = \frac{\$4{,}763}{(1.05)^{60} - 1} - \frac{\$5}{0.05} = \$169.42$$

All of the information needed to determine the value of the tract – timber and land – is now available. The timber itself is worth \$5,948 per acre, and the land is worth \$169.42 per acre; thus, the total value of the tract is \$6,117.42/ac. This total value is the Forest Value under the given assumptions.

In the previous example it was assumed that the stand would be harvested and regenerated immediately. In that case, the Forest Value is just the value of the standing timber plus the LEV. The following example considers the case where the stand in the previous example is not harvested immediately.

Forest Value Example #2

In the previous example, one alternative to harvesting the stand is to leave it alone and consider cutting the stand later. Let's say that you used a local growth simulator and estimated that the stand volume would increase to 24 mbf of sawtimber and 12 cords of pulpwood per acre if the stand was left alone for another ten years. Should you let the stand grow for another 10 years?

Answer: In order to answer this question, we calculate the Forest Value for the tract, assuming that it will be cut in 10 years. If this Forest Value is higher than the Forest Value obtained by cutting the stand now, then the stand should not be cut now. We start by calculating the present value of the remainder of the current rotation. All values will be expressed on a per-acre basis. In ten years, you will be able to sell the timber for:

$$Timber\ value = \sum_{p=1}^{2} P_p Y_{p,10} = \$325/mbf \times 24mbf + \$7/cd \times 12cd$$
$$= \$7{,}884$$

Of course, you have to wait ten years before you can realize this timber value, so to compare it to the case where you harvest immediately, it is necessary to discount this value:

$$PV_{Timber} = \frac{\$7,884}{(1.05)^{10}} = \$4,840.09$$

This is not quite the present value of the rest of the current rotation. During the next ten years, taxes will have to be paid on the property. To account for this, it is necessary to subtract the present value of ten annual tax payments (calculated with the finite annual series formula):

$$PV_{taxes} = \frac{\$5\,[(1.05)^{10} - 1]}{0.05\,(1.05)^{10}} = \$38.61$$

Thus, the net present value for the remainder of the current rotation is $4,801.48 ($4,840.09 - $38.61). Now, after harvesting the stand in ten years, you will have bare land, and the LEV calculated earlier indicates that this bare land will be worth $169.42 per acre. Note that this gives the present value of all of the future rotations on the site, but if you wait ten years to harvest the current stand, those future rotations won't start for another ten years. Thus, the bare land value must also be discounted for ten years before it is added to the present value of the current rotation.

$$PV_{LEV} = \frac{\$169.42}{(1.05)^{10}} = \$104.01$$

The Forest Value when the harvest is delayed for 10 years is therefore $4,905.49 ($4,801.48 + $104.01). Compare this with the Forest Value if the tract is harvested now — $6,117.42. You would lose $1,211.93 per acre if you delay harvesting the stand for ten years.

Note in this second example that the value of the land is always the same, regardless of when you plan to harvest the timber. Since the productive capacity of the land does not change, the land value should not change from one year to the next unless your expectations regarding future prices, costs or yields have changed. Thus, to calculate the value of just the timber in this second example, you would take the Forest Value minus the (undiscounted) LEV; i.e, it is $4,736.07 ($4,905.49 - $169.42). Note that this is not the same as the present value of the timber harvest, which is $4,840.09, or the present value of the costs and revenues for the remainder of the current rotation, which is $4,801.48. Keep in mind also that when we use the LEV as an estimate of the value of the bare land, we are assuming that the management regime we are planning to implement for future rotations is the most valuable use of the land.

2. Definition of the Forest Value

The examples in the previous section illustrated the application of the Forest Value to a relatively simple example. This section gives a formal definition for the Forest Value and describes the assumptions behind the Forest Value. The next section presents a general formula for calculating the Forest Value.

> The *Forest Value* is the present value, per unit area of forest, of the projected costs and revenues from a forested tract with or without an existing stand of timber, and on which an infinite series of identical future even-aged forest rotations will also be grown. The Forest Value includes the value of both the trees (if there are any) and the land.

In the even-aged case, it is assumed that:

i) the current stand will be harvested, either now or at some point in the future, and
ii) it will be replaced with a new stand, and
iii) all future rotations (after the current one) will be identical, with rotations of equal length and identical net revenue streams within a rotation.

Note that while the management regimes for all future rotations are assumed to be identical, they are not necessarily expected to be the same as the management regime of the current stand, and harvest timings, yields, prices and costs can be different for future stands than for the current stand. For example, the current stand could be a natural pine stand which is expected to be converted to a managed pine plantation, or it could be an oak-hickory stand that is expected to regenerate as a red maple stand.

3. Calculating the Forest Value

As is often the case, it is necessary first to define some new notation for the new concepts that have been introduced. Let:

T_0 = the time when the current stand is to be harvested,
$Y^C_{p,To}$ = the expected yield of product p from the current stand at time T_0, and
C_h^C = the cost of selling the current stand of timber.

The following formula can be used to calculate the Forest Value for a stand that will be harvested in T_0 years:

$$Forest\,Value = \frac{\sum_{p=1}^{n} P_p Y^C_{p,T_0} - C^C_h}{(1+r)^{T_0}} + \frac{A[(1+r)^{T_0} - 1]}{r(1+r)^{T_0}} + \frac{LEV}{(1+r)^{T_0}}$$

The first two terms in this expression give the present value of the costs and revenues through the end of the current rotation. The first term gives the present value of the net revenue from the harvest of the current stand, and the second term gives the present value of the annual net revenue incurred up to the end of the current rotation. (Remember, if the annual net revenue is a cost, such as an annual property tax, *A* will be negative.) The third term in the Forest Value formula is the LEV value for the future rotations planned for the site, discounted for T_0 years. This term gives the present value of all of the future rotations on the tract. If there are other intermediate costs or revenues that are expected to occur between now and the time when the current stand is harvested (i.e., T_0), then terms for those costs or revenues would also have to be added to the formula. They have been left out of the formula to keep it from being unnecessarily complicated.

Note that if a stand is going to be harvested right now (i.e., if $T_0 = 0$), then the above formula simplifies to:

$$Forest\,Value = \sum_{p=1}^{n} P_p Y_{p,0}^{C} - C_h + LEV$$

In this case, the Forest Value is just the value of the timber plus the LEV. This was the case in the first example above. If the timber has just been harvested but no new stand has been established, then the Forest Value equals the LEV.

4. <u>Separating the Land Value from the Value of the Trees</u>

Because the third term in the Forest Value formula includes the LEV, it is often assumed that the third term gives the value of the land and the first two terms give the value of the timber. This is not the case. This section addresses the question of how to separate the land value from the timber value. To do this, it is necessary to keep in mind one basic assumption that is made in the Forest Value formula given in this chapter:

- ☞ The *land value* is always equal to the LEV.

The qualities of forest land do not change substantially because of the age of the timber that is growing on it. The value of the land does, of course, depend on what can be grown there, but it does not depend on what is there right now. As long as the basic factors affecting the land value – e.g., expected prices, costs, yields, etc. – are not changed, the land value should not change. The forest cover could always be removed from a site and a new stand started. If the trees were removed and a new rotation started, then the present value of all expected future costs and revenues would be given by the LEV. This is the value of the land, and it is always the value of the land – as long as the new stands that will be grown on the site represent the best use of the land. Under this assumption, the value of the land without the trees is always equal to the LEV.

Since the Forest Value is the value of the land plus the trees, the *timber value* must be equal to the Forest Value minus the LEV. Thus,

☞ Timber Value = Forest Value - LEV

Substituting the formula given above for the Forest Value into this expression results in the following formula for the timber value:

$$Timber\ value = \frac{\sum_{p=1}^{n} P_p Y_{p,T_0}^C - C_h^C}{(1+r)^{T_0}} + \frac{A[(1+r)^{T_0} - 1]}{r(1+r)^{T_0}} + \frac{LEV}{(1+r)^{T_0}} - LEV$$

This expression can be simplified. First, multiply the last term by $(1+r)^{To}/(1+r)^{To}$:

$$Timber\ value = \frac{\sum_{p=1}^{n} P_p Y_{p,T_0}^C - C_h^C}{(1+r)^{T_0}} + \frac{A[(1+r)^{T_0} - 1]}{r(1+r)^{T_0}} + \frac{LEV}{(1+r)^{T_0}} - \frac{(1+r)^{T_0}\ LEV}{(1+r)^{T_0}}$$

Now, combine the last two terms and multiply the combined term by r/r:

$$Timber\ value = \frac{\sum_{p=1}^{n} P_p Y_{p,T_0}^C - C_h^C}{(1+r)^{T_0}} + \frac{A[(1+r)^{T_0} - 1]}{r(1+r)^{T_0}} - \frac{r\ LEV[(1+r)^{T_0} - 1]}{r(1+r)^{T_0}}$$

The last term in this equation is the present value of a finite annual payment of $r \times LEV$ which is made through the end of the current rotation. This annual cost is an implicit rental charge for the use of the land through the end of the current rotation. The formula can be simplified further:

$$Timber\ value = \frac{\sum_{p=1}^{n} P_p Y_{p,T_0}^C - C_h^C}{(1+r)^{T_0}} - \frac{(r\ LEV - A)[(1+r)^{T_0} - 1]}{r(1+r)^{T_0}}$$

The term $r \times LEV - A$ is the annual land cost. If the only annual cost or revenue is the annual property tax (i.e., $A = -t_{prop}$), then the annual land cost is $r \times LEV + t_{prop}$, i.e., the annual rent plus the annual property tax. Now, the timber value can be interpreted as the present value of the final harvest revenue minus the present value of the annual costs of using the land and of paying the annual property tax through the end of the current rotation. The *liquidation value* of timber is what it is worth if it is cut and sold immediately. As long as the liquidation value of the timber is less than the value of the timber given by the equation above for some $T_0 > 0$ then the timber is worth more being left to grow than it is worth being cut down. In these cases, the timber is considered financially immature. At some age, this will no longer be true – there will be no $T_0 > 0$ where the equation above will give a greater value than the liquidation value. At this point, it is time to harvest the timber. It shouldn't surprise you that the age where this occurs also happens to be the age where the LEV reaches its maximum, or the financially optimal rotation age. For ages older than the financially optimal rotation age, the liquidation value of the timber will be greater than the timber value given by the above equation for all values of $T_0 > 0$. At this point, the timber is considered financially over-mature.

5. Calculating the Forest Value With Changing Real Prices

One of the most significant limitations of the LEV is the assumption that prices and costs will remain constant for all time. (The most significant limitation is that it only applies to bare land.) However, in some cases stumpage prices in an area do show increasing trends, and it is often not unrealistic to think that real stumpage prices may increase further. It is unlikely, however, that real stumpage prices will go up forever. If that were to happen, then wood would eventually become too expensive to use in most applications, and people would find cheaper raw materials to substitute for wood.

This section relaxes the assumption of constant prices. Real prices will be assumed to go up for some finite time period, after which real prices will be assumed to stabilize and remain constant for the rest of time. Assumptions such as these are highly speculative. However, to assume that prices will remain constant is equally speculative and sometimes clearly unrealistic. While no one knows for sure what the future may hold, some guesses are better than others. If you think it is likely that stumpage prices will go up in your area, then you will need to know how to consider such changes in your calculations. You may want to consider a variety of scenarios in deciding what is best to do. In general, however, you should keep in mind that assumptions that we make about the near future are far more critical than the assumptions we make about the distant future. The discounting process tends to significantly diminish the impact on present decisions of values for the distant future.

As in earlier sections of this chapter, it may be helpful to begin with an example.

Forest Value Example #3

Recall the example that was used in Section 1 to introduce the concept of the Forest Value. The tract in the example was a mature northern hardwood stand, and the two management options that were considered were: 1) to clearcut the stand now, or 2) to wait ten years to clearcut the stand. Under the assumptions that were made earlier, the option of cutting the stand immediately was the clear winner.

Here we will change the assumptions about future stumpage prices and re-analyze the example. Assume that over the next 10 years real sawtimber and pulpwood stumpage prices are going to increase to $450/mbf and $15/cord, respectively. (In the previous example, they were $325/mbf and $7/cord. What real rates of price increase does this imply for the next 10 years?) All of the other assumptions of the problem will be left as they were. Table 7.1 summarizes these remaining assumptions. Under the new assumptions about prices, should the current stand be harvested now or in 10 years?

Table 7.1. Assumptions for Forest Value example with changing prices.

Item	**Amount**
Assumptions for the Current and Future Stands	
Current sawtimber volume	18 mbf/acre
Current pulpwood volume	14 cords/acre
Current sawtimber price	$325/mbf
Current pulpwood price	$7/cord
Expected sawtimber volume in 10 yr	24 mbf/acre
Expected pulpwood volume in 10 yr	12 cords/acre
Expected real sawtimber price after 10 yr	$450/mbf
Expected real pulpwood price after 10 yr	$15/cord
Annual property tax	$5
Real alternate rate of return	5%
Assumptions about Managing Future Stands	
TSI (age 30) pulpwood harvest	12 cords/ac
Final (age 60) sawtimber harvest	13 mbf/acre
Final (age 60) pulpwood harvest	25 cords/acre

Answer: The value of the harvest if the stand is cut now has not changed because the assumptions about current prices are unchanged.

$$Timber\ value = \sum_{p=1}^{2} P_{p,0} Y_{p,0}^{C} = \$325/mbf \times 18mbf + \$7/cd \times 14cd$$
$$= \$5{,}948$$

The next step is to calculate the LEV. However, unlike the timber value, the LEV does change under the new assumptions about prices. The LEV must be recalculated with the new expected future prices since all of the harvests associated with future rotations will happen more than 10 years from now – after prices are assumed to have gone up. Again, using *method 3* for calculating the LEV, we ignore the annual tax and calculate the future value of the first rotation:

$$FV_{R_1}^{'} = 12 \times \$15 \times (1.05)^{30} + 13 \times \$450 + 25 \times \$15 = \$7{,}002.95$$

Now, the LEV equals:

$$LEV = \frac{FV'_{R_1}}{(1+r)^R - 1} - \frac{tax}{r} = \frac{\$7{,}002.95}{(1.05)^{60} - 1} - \frac{\$5}{0.05} = \$296.11$$

So the Forest Value, assuming that the current stand is harvested immediately, equals:

$$ForVal_{cut\ now} = \$5{,}948 + \$296.11 = \$6{,}244.13$$

Now, consider the case of harvesting the current stand in 10 years. The expected future value from the harvest of the current stand is:

$$Timber\ value = \sum_{p=1}^{2} P_{p,10} Y^{C}_{p,10} = \$450/mbf \times 24mbf + \$15/cd \times 12cd$$
$$= \$10{,}980$$

The present value of the timber harvest is:

$$PV_{Timber} = \frac{\$10{,}980}{(1.05)^{10}} = \$6{,}740.77$$

Again, it is necessary to subtract the present value of ten annual tax payments. This value, \$38.61, has not changed. Thus, the net present value of the costs and returns from the remainder of the current rotation is \$6,702.16 (\$6,740.77 - \$38.61). The discounted LEV is:

$$PV_{LEV} = \frac{\$296.11}{(1.05)^{10}} = \$181.79$$

Thus, under our new assumptions about prices, if the harvest is delayed for 10 years, the Forest Value will be:

$$ForVal_{cut\ in\ 10\ yr} = \$6{,}702.16 + \$181.79 = \$6{,}883.95$$

Compare this with the Forest Value if the tract is harvested now – \$6,244.11. Under the new assumptions about price changes, waiting is the better option, and you would be giving up \$639.83 per acre if you harvest now.

This example illustrates how different assumptions can lead to different conclusions. If you assume real prices will remain constant, then harvesting the stand now is clearly the best alternative, financially. If you assume that real prices will increase substantially over the next 10 years, then you should wait to harvest the stand in order to take advantage of the price increases.

There is no absolute answer to the question of which management alternative is best, and no amount of financial analysis will provide such an answer. The option you choose will ultimately have to depend on your judgement of which set of assumptions more closely matches what will actually happen. One thing you might want to do in a case like this is to calculate a rate of price change for sawtimber prices that would make the Forest Values of the two options – cutting now versus cutting in 10 years – equal (what you assume about pulpwood prices is less important since it is a relatively small part of your revenues). Once you know the break-even rate of price change, you can ask yourself whether you think sawtimber prices will go up faster or slower than the break-even rate. If you think prices will most likely go up faster than that rate, then you should wait to harvest the stand. Otherwise, the stand should be harvested now.

The Forest Value Formula With Changing Prices

Allowing real prices and costs to change over time does not require any substantial changes in the notation for the forest value formula. Any price or cost that may change with time will need a new subscript indicating the period to which that price corresponds. Thus, the notation for product prices changes to:

$P_{p,t}$ = the price of product p in period t.

As with the notation, the only changes in the formulas are subtle. The formula for the Forest Value when prices are expected to change is:

$$Forest\,Value = \frac{\sum_{p=1}^{n} P_{p,T_0} Y_{p,T_0}^{C} - C_h^{C}}{(1+r)^{T_0}} + \frac{A[(1+r)^{T_0} - 1]}{r(1+r)^{T_0}} + \frac{LEV}{(1+r)^{T_0}}$$

Note that now we use the price of product p at T_0 (i.e., P_{p,T_0}) to calculate the value of the final harvest of the current crop of trees. Also, note that any prices used in the calculation of the LEV must be prices that we expect after the price changes stabilize. In other words, as mentioned earlier, it is assumed here that real prices will eventually settle down to some steady state. Those steady state prices should be used in the LEV. Thus, the LEV formula should also be modified as follows:

$$LEV = \frac{-E(1+r)^R + \sum_{t=1}^{R-1} I_t (1+r)^{(R-t)} + \sum_{p=1}^{n} P_{p,\infty} Y_{p,R} - C_h}{(1+r)^R - 1} + \frac{A}{r}$$

(This is the formula for calculating the LEV with *method 3*.) Note that the notation $P_{p,\infty}$ is used here to denote the steady-state prices. (The symbol ∞ stands for infinity.) Note also that intermediate costs and returns may also be affected by different assumptions about changing real costs and prices. It is important that you understand what prices are supposed to be at a particular time, rather than relying on formulas to tell you what to do. It may help to draw yourself a graph of prices over time.

Price Changes That Are Expected to Continue into the Next Rotation

The examples in this book always assume that price changes will end by the time the next rotation begins. Obviously, in a real-world situation you may wish to assume that the prices will continue to change for a longer period than this. In such a case, you would need to do a separate present value calculation for each rotation until after the price changes end and prices reach a steady state. The LEV formula – as it has been presented here – can only be used for rotations that occur after all prices and costs have settled down to a steady state. As you might guess, performing separate present value calculations for more than two or three rotations can be messy and complicated. If you need to do such a calculation, it is particularly important that you understand the basic concepts we have covered so far and that you are careful and well-organized. However, such problems are generally beyond the scope of this book, so we won't pursue their solution further here.

6. <u>Study Questions</u>

1. How does the Forest Value generalize the concept of the LEV?

2. Briefly describe in layman's terms (no equations) what the forest value is. What are the assumptions made in calculating a forest value?

3. What kinds of questions is the Forest Value useful for addressing?

4. Why are the assumptions that apply to the current stand more important than the assumptions that apply to future rotations?

5. Why is the value of the land always equal to the LEV – even when there is a stand of timber on the land?

6. Why is the value of the standing timber not simply equal to the present value of the future expected net revenue from harvesting the current stand?

7. Explain why the value of immature timber is usually greater than its liquidation value.

8. When is the value of standing timber equal to its liquidation value?

9. Why is it not likely that real stumpage prices will continue to rise forever?

7. Exercises

*1. You are in charge of the Transcontinental Paper Company's spruce genetics program in Maine. You have obtained the following yield data from some trials of a new, genetically improved variety of red spruce.

Table 7.2. Yields, MAIs, and LEVs for the new variety of red spruce.

Age	Yield (cords)	MAI	LEV
45	51		$37.46
50	63		$39.02
55	73		
60	82		

a. Calculate the mean annual increment (MAI) for ages 45, 50, 55, and 60 and fill in the third column in the table. (Don't worry about the LEV column for now.)

b. What is the average annual percentage rate of growth between ages 45 and 55?

c. Calculate the LEV for plantations of the new spruce variety for a 55 year rotation. Use the following price and cost data (assume all prices and costs will increase at about the same rate as inflation). The LEVs for 45 and 50-year rotations have already been calculated.

- Planting cost: $145/ac.
- Release cost at age 3: $50/ac.
- Annual taxes: $2/ac.·yr.
- Spruce pulp price: $30/cd.
- Real interest rate: 4%.

d. You have some existing stands of spruce that you are considering harvesting and replacing with the new fast-growing variety. One of these stands currently has a volume of 48 cd/ac and is expected to grow another 10 cd/ac over the next 5 years. Should you cut this stand now or wait 5 years before harvesting it?

2. You are considering planting blue-white pine (*Pinus nittannii*) on your client's property and have obtained the following volume prediction equation for the species:

$$Yield\ (m^3/ac.) = 400 \times e^{[-8 \times (Age - 11)^{-0.4}]}$$

a. Fill in the second column of Table 7.3. below by calculating the expected yields for ages 25, 30, 35, and 40. The yield at age 45 has already been calculated for you.

b. Calculate the mean annual increment (MAI) for ages 30 through 45 and fill in the third column in Table 7.3. Show at least one sample calculation.

c. Calculate the annual percentage growth rate fore each 5-year interval between ages 25 and 45 and fill in the fourth column in Table 7.3. Show at least one sample calculation.

Table 7.3. Expected yields and LEVs for *Pinus nittannii* stands.

Age (yrs)	Yield (m^3/ac)	MAI (m^3/ac·yr)	Percent Growth	LEV ($/ac)
25				
30				
35				
40				
45	56.79			40.08

d. Calculate the LEV for a rotation age of 30, and complete the table. (The LEV for a rotation of 45 years has already been calculated.) Use the following economic assumptions:

- Establishment cost = $180/ac.
- Precommercial thin at age 18 costs $75/ac.
- Pine stumpage sells for $30/$m^3$.
- Real alternate rate of return is 4%.
- Annual property taxes are $2/ac.
- All costs and prices are expected to increase at the rate of inflation.

e. If the client in problems 3 and 4 said that he would prefer to grow the pine on a rotation of 40 years instead of the one that gives the maximum LEV, what would be the opportunity cost of this decision (per acre)?

f. The client in problem 4 has a 60-acre stand of 25-year-old blue-white pine. Assume the yield data in Table 7.3 and economic data from part d also apply to this stand. Assume that the stand will be harvested at age 30 and replanted with blue-white pine. Future stands will also be managed on 30-year rotations. What is the Forest Value (per acre) of this 25 year old stand?

g. What is the value of the trees on the 25-year-old blue-white pine stand described in part f?

3. You are a self-employed forestry consultant, just starting your own business in southern Louisiana. A young couple, Wendell and Lorna Toussaint, have just inherited 40 acres of natural pine from a great-uncle. Their primary objective for managing the land is to generate income. They have hired you to tell them what to do. In discussing their financial objectives with them, you have determined that an appropriate (nominal) alternate rate of return for them is 8%. Following some additional discussion, they agreed that it is reasonable to expect inflation to be about 4% for the foreseeable future. They have told you that the current annual tax on the property is $5/acre, and they agreed that over the long run these taxes are likely to increase at about the same rate as inflation. You also have reminded them that there is a severance tax on timber of 5% for pulpwood and 3% for sawtimber.

Next, you went out and measured a few plots. The stand of trees is fairly homogeneous in terms of stocking and age. You have estimated the site quality to be about medium (site index in the range of 50 to 60). Your first impression is that the stand is close to rotation age and should be replaced with a pine plantation to maximize financial return. You have discussed this with the Toussaints, and based on this discussion you have agreed to consider two alternatives: cut now and plant pine as soon as possible or wait 5 years and then cut and plant pine. The following table describes some of the information you have gathered.

Table 7.4. Current-stand yield and economic data for the Toussaint's natural pine stand.

Item	Amount
Initial pulpwood volume	25 cords/ac
Current pine pulpwood price	$25.00/cd
Initial sawtimber volume	8 mbf/ac
Current pine sawtimber price	$280.00/mbf
Predicted 5-yr pulpwood growth	1 cords/ac
Expected (nominal) pulpwood price in 5 years	$32.00/cd
Predicted 5-yr sawtimber growth	2 mbf/ac
Expected (nominal) sawtimber price in 5 years	$360/mbf
Estimated planting cost (likely to increase at same rate as inflation)	$180/ac
Estimated release cost at age 5 (likely to increase at same rate as inflation)	$50/ac

While you expect real pulpwood and sawtimber prices to increase over the next 5 years (verify this for yourself), you think the real price increases will likely end eventually, and decide to assume constant real prices after year 5. As stated in the table, you expect planting and release costs to increase at about the rate of inflation.

Table 7.5 lists your expected yields for the pine plantation that will be established following the harvest of the current stand. Now, determine which of the two proposed management alternatives is best and write a report for the Toussaints outlining your recommendation and briefly describing your analysis.

Table 7.5. Expected yields for pine plantations to be established on the Toussaint tract.

Age	Pulpwood (cords)	Sawtimber (mbf)
20	20	0
25	22	2.5
30	23	5.0
35	24	7.0
40	23	8.5