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Financial Analysis for Tree Farming in Hawaii

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This publication provides information for tree growers, forestland managers, and forestry extension workers on how to estimate the economic value of trees and forestland.

Tree farmers in Hawaii grow trees for many reasons: for forest restoration, for conservation of native species, for recreation, and as a business. If you are growing timber as an investment, you need to be able to analyze the profitability of your business. Economic decisions tree farmers face include which tree species to grow, when to harvest, and when to replant. You may also wish to compare the financial benefits you would obtain from your forestry activity with those you would obtain from other land use alternatives, such as ranching or hunting. A key difference between the economics forestry and most agricultural land uses is that the financial returns to forestry are often delayed for years. Therefore, you need to take the time value of money into account when planning investments in forestry.

Financial calculations give you answers to hypothetical questions. You have to supply the growth rates, prices, and costs particular to your situation. The answers you get will be only as good as the data you use. You can think of financial analysis as a framework to organize your thoughts and help set directions. Following are answers to some questions that you might ask.

How should I value time?

In forestry, revenues include income from thinning and sales at harvest, while costs may include expenses for stand establishment, forest management, taxes, and harvesting. The value of time affects both revenues and costs. Revenues are worth more if earned earlier, while costs are less costly if incurred later. In long-term business projects, time thus has a complex effect on the value of revenues and costs and, hence, profits.

What is discounting?

The value of time is accounted for by applying an interest rate referred to as the discount rate. For example, suppose you have $100 now, which you will invest for 10 years with a 6% annual interest rate, compounded annually. To find out how much your $100 will become 10 years from now, you use the following formula:

$$FV = PV(1 + i)^n$$

where: FV = future value
PV = present value
i = discount rate
n = number of years

so you have: $FV = 100(1 + 0.06)^{10} = 179.08$

Thus $100 invested today and earning a 6% annual interest rate will be worth $179.08 in 10 years. This process of converting a present value to a future value is called compounding.

Likewise, you can also convert a future value to a present value by discounting. One hundred dollars to be received 10 years from now will be worth less today because of the time value of money. The formula to get the present value of $100 to be received 10 years from now with a 6% annual interest rate is

$$PV = \frac{FV}{(1 + i)^n} = \frac{100}{(1 + 0.06)^{10}} = 55.84$$

Therefore, $100 to be received 10 years from now is worth only $55.84 today.

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How do I measure profitability?

The example of calculating the present value of $100 to be received 10 years from now illustrates how you can determine the economic value of your long-term forestry business. Basically, you balance your present revenue and costs (such as costs of site preparation and seedlings) against your future revenues and costs (such as revenues from thinning and harvesting). For each year of the project, you sum your revenues and costs for that year to come up with an annual net revenue. Each annual net revenue is then discounted by the appropriate number of years, back to the present. The sum of all the discounted annual net revenues gives you the net present value (NPV) of the project. Calculations of NPV can readily be done with computer spreadsheets or financial calculators.

If you have several forestry projects or other land use alternatives open to you, such as ranching or hunting, you can rank them by comparing their NPVs. The project with the highest NPV would be the most economically beneficial.

How does the internal rate of return (IRR) relate to NPV?

When you calculate your NPV, you select an interest rate (the discount rate) that you could earn if you invested your money in the next best alternative. In our example above, this was a 6% annual interest rate. The IRR, on the other hand, reflects the interest rate that you earn from investing in your forestry project. You calculate the IRR by finding the discount rate that makes the NPV equal to zero. The IRR is another measure of profitability that you can use to compare different projects or investments.

How should I account for inflation?

If you assume all prices and costs will rise at the same rate, you can leave inflation out of your calculations altogether. Real prices and real interest rates are those not adjusted for inflation. The interest rates offered by banks are nominal rates, which are real rates plus an adjustment to allow for inflation. If inflation is expected to be 2%, then the 6% nominal interest rate is equivalent to a 4% real interest rate. In your economic calculation, you may use real interest rates and prices or nominal interest rates and prices adjusted for inflation, but you must be consistent in any given calculation.

How should I account for the cost of the land?

If you own land and are deciding whether to grow trees or another crop, it is easiest to leave land cost out of the calculations, as it will be the same for all your alternatives. If you will be purchasing or leasing land as part of an investment in tree farming and you are considering other investments, you should include the interest on the mortgage or lease payments in your costs.

At what age should I harvest my trees?

Trees grow continuously, but their growth rate decreases over time. You should harvest when tree growth slows to the point that you would be better off harvesting and selling them and planting a new crop. Specifically, you should harvest when the trees reach their maximum NPV. You do this by calculating NPVs for all years in which harvesting could occur, then selecting the year for which the NPV is greatest. This is your theoretical optimum year of harvest.

The age when the trees are harvested is called the rotation. Rotations may be short (e.g., 12–15 years for some *Eucalyptus* species), or they may be long (e.g., 80 years for some slow growing, high-value hardwoods. Shorter rotation periods would result also from higher discount rates because of the relatively greater opportunity cost of leaving the trees in the ground longer. On the other hand, larger trees, although they take longer to grow, may be able to be sold at a premium because they can be used for high-value products, such as veneer.

In the real world, timber and stumpage prices cycle up and down. (Stumpage price is the value of timber as it stands uncut, i.e., the amount paid by the logger to a landowner for the right to harvest trees). To maximize net returns, you can delay harvesting if prices are low and wait out the cycle. Alternatively, tree farms can serve as “money in the bank” for future anticipated expenses such as school tuition.

Can I convert NPV to an annual basis to compare forestry with other land uses which could provide annual income?

Yes, there are two ways of doing this. First, if you plan to grow trees for only a certain period (e.g., 60 years), you can convert your NPV into an annual amount for 60 years. This is called the equivalent annual income (EAI) and the formula is

$$EAI = NPV \frac{i(1+i)^n}{(1+i)^n - 1}$$

where n is the number of years in the rotation (an example is shown below).

Second, if you plan to grow trees perpetually, you calculate a land expectation value (LEV). The land expectation value is the present value of a perpetual periodic series, and it represents the value of the bare land if used to grow trees. It is calculated as follows:

$$LEV = \frac{FV_n}{(1+i)^n - 1}$$

where

FV_n = net future value at the end of the first rotation and

n = number of years in the rotation (an example is shown below).

If you have already calculated the EAI, the LEV may be calculated as simply

$$LEV = \frac{EAI}{i}$$

You may use EAI and LEV to compare investments of different duration, such as shorter rotations and lower-value species versus longer rotations and higher-value species. You may also use them to compare annual incomes derived from forestry, where your income is delayed, to other land uses such as ranching or planting agricultural crops, where your income is received yearly. Since EAI and LEV are "annualized" versions of NPV, the investment with the highest EAI or LEV would be the most economically beneficial for you. Note, however, that the formulas presented here are just for a single stand of trees. A tree farm or forest, once established, will consist of many stands of trees of different species and different ages. These will be harvested at different times, giving a more constant flow of income. An economic analysis of an established tree farm with stands of many different ages would be a combination of the individual analysis for each stand.

A sample analysis of a teak tree farm in Hawaii

The following example shows how a particular grower might calculate expenses and returns on a tree farm. Teak was chosen as an example because it has been widely grown around the world, and its growth rates and rotation ages are relatively well known. The costs reflect typical expenses to establish a small (10–50-acre) tree farm on the island of Hawaii in 1999. Costs used in the calculations are given in Appendix 1. Larger tree farms will have economies of scale, which will lower per-acre costs. The only management cost included in the example is for a professionally prepared management plan at establishment. If a professional manager is employed for the life of the project, annual management costs need to be included. We have assumed that the landowner already owns the land and would be keeping it in agriculture in any case, so land costs (lease or mortgage payments) and property taxes are set to zero. Some counties in Hawaii offer low property tax rates if land is used for forestry. The difference between what you would otherwise pay and the forestry property tax rate could be counted as income. Income and capital gains taxes are not included in this analysis. If you enroll in a government-sponsored cost-share program, you will be eligible for rebates for part of your costs. *You should estimate your own costs*, which will vary depending on the soil type, accessibility of the site, its current vegetation, the cost of seedlings, and other factors. Clearly, it is important to keep good records of your costs and revenues if you want to be able to calculate the value of your investment in forestry. As your plantation grows, you will be able to substitute real costs for your estimated ones and make more accurate projections of growth and income.

Yields

Hypothetical yields in thousands of board feet per acre (mbf/acre) are given in Appendix 2 for rotation ages from 25 to 60 years. These yields assume that the entire plantation is harvested at one time. It would, of course, be possible to harvest one part of the plantation at one time and another later. In that case, the economic analysis should be done separately for each part. The yields given are conservative estimates for a well managed teak plantation, appropriately fertilized and thinned, growing in a low-elevation area receiving more than 80 inches of rainfall per year. Yield rates were based on a wide variety of international trials, none in Hawaii. *You should create your own yield rates* based on your particular species and site conditions.

Stumpage prices

Teak is one of the most valuable woods in the world, with sawlogs selling internationally for $1300 per cubic meter—about $4300 per thousand board feet (mbf)—and finished lumber selling at $15 per board foot in Hawaii in 1999. Teak lumber from rapidly grown plantations, however, may be of lower quality and may not be as valuable as the teak lumber from native forests on the market today. Stumpage rates here were estimated as being greater than stumpage for eucalyptus, about $500/mbf and less than stumpage for koa, about $2500/mbf in Hawaii in 1999. Stumpage in this example was assumed to be constant relative to prices in general. If you believe that timber prices will change in comparison to prices in general (i.e., that there will be a real price increase or decrease), you could increase or decrease stumpage prices (for example, ½–1 percent per year.)

The sample analysis below (Table 1) was carried out on a computer or electronic spreadsheet.

Net revenue and NPV

Annual net revenue is calculated as the sum of all revenue, if any, less all costs, for each year. Net revenue is negative until year 15, the second thinning, which is the first year any income is received from the plantation. The annual cost of $25/acre for maintenance for years 7–14 and years 16–34 is not shown here but was included in the calculations.

NPV was calculated by using the NPV function of the computer spreadsheet for the entire 35-year stream of net revenues. The spreadsheet function discounts each annual net revenue by the appropriate number of years and sums the result.

Sensitivity analysis

Using a spreadsheet allows you to change stumpage prices, growth figures, discount rates, costs, and other variables and quickly see how these changes affect your NPV (Table 2). Because you can only estimate future growth rates, discount rates, and prices, it is important to do these sensitivity analyses. Sensitivity analysis allows you to see how far off your projections will be if your initial assumptions are incorrect.

The effect of different discount rates (same stumpage price)

For every year, the NPV is lower with a 7% discount rate than with a 4% discount rate. This is because a higher discount rate decreases the value of eventual revenue, while initial costs remain the same. Indeed, at the higher discount rate NPV is negative (the tree farm loses money) at all but the highest stumpage prices.

Table 1. Sample annual net revenue and NPV calculations for a 50-acre teak plantation in Hawaii. Stumpage is assumed to be $1,000/mbf, and the discount rate is 4%. Numbers in parentheses are negative.

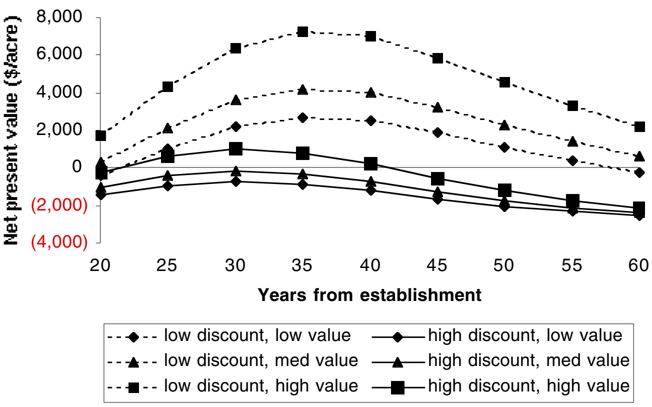
Year	Cost	Revenue	Annual net revenue
	$/acre		
1	(2,255)	0	(2,205)
2	(230)	0	(230)
3	(230)	0	(230)
4	(230)	0	(230)
5	(325)	0	(325)
6–14	(25)	0	(25)
15	(25)	109	84
16–34	(25)	0	(25)
35	(25)	23,900	23,875

NPV = 2,713

Table 2. Sample sensitivity analysis of the NPV for a teak plantation in Hawaii. Maximum NPV for each scenario is in bold. Negative numbers are in parentheses.

	Stumpage					
	$1,000/mbf		$1,250/mbf		$1,750/mbf	
	Discount rate					
	4%	7%	4%	7%	4%	7%
Year	Net present value, $/acre					
20	(387)	(1,424)	320	(1,023)	1,735	(222)
25	1,084	(915)	2,171	(381)	4,347	688
30	2,271	**(694)**	3,666	**(99)**	6,456	**1,090**
35	**2,713**	(846)	**4,227**	(287)	**7,255**	832
40	2,564	(1,191)	4,048	(716)	7,016	236
45	1,912	(1,625)	3,239	(1,256)	5,892	(518)
50	1,159	(2,003)	2,302	(1,727)	4,589	(1,176)
55	444	(2,299)	1,413	(2,096)	3,350	(1,691)
50	(192)	(2,522)	621	(2,375)	2,246	(2,079)

Figure 1. Finding the maximum NPV for a teak plantation in Hawaii for different stumpage rates and different discount rates.



You will notice that NPV reaches a maximum in each scenario and then declines (Figure 1). That is because tree growth rate is assumed to decline gradually over time, and after a time growth does not keep up with interest rates. You may also note that the maximum NPV with 7% comes earlier, at year 30, than the maximum NPV with 4%, which comes later at year 35. This illustrates that higher discount rates will result in shorter rotation periods.

The effect of different stumpage prices (same discount rate)

Unlike changes in discount rate, changes in stumpage price do not affect the rotation length. If stumpage price increases over time, however, the rotation becomes longer. This is because the rate of increase serves as an offset to the discount rate. The break-even price is the price at which the NPV at a given discount rate goes to zero. You may calculate a break-even price by entering various prices in the spreadsheet until the NPV becomes zero. For the example given, break-even prices are as follows:

Break-even prices at two discount rates

Discount rate (%)	Break-even price/mbf
4	$552
7	$1292

Internal rate of return (IRR) calculations

As discussed above, the internal rate of return (IRR) is the discount rate at which the NPV equals zero. You may calculate IRR using the spreadsheet by trying different interest rates until the NPV reaches zero. For the three timber prices in the example, the IRRs would be as follows:

Internal rates of return at three stumpage prices

Stumpage ($/mbf)	IRR (%)
1,000	6.0
1,250	6.7
1,750	8.1

Remember that these are real rates net of inflation; to compare with other investments, you would have to add anticipated rates of inflation to each.

Conversion to equivalent annual income

Let us say you plan to grow teak for a fixed period of 35 years and you would like to know your equivalent annual earnings for that period. With a discount rate of 4% and a stumpage price of $1,000/mbf, your NPV is $2,713 (see Table 1). To convert this to an annual amount, you determine your EAI as follows:

$$\text{EAI} = 2713 \frac{0.04(1 + 0.04)^{35}}{(1 + 0.04)^{35} - 1} = 145$$

This means that you would receive an amount equivalent to annual income of $145/acre/year for 35 years. You may then compare this amount to another alternative source of annual income. The equivalent annual income may also be calculated using the payment function (PMT) on a computer spreadsheet. Along with the discount rate and number of years in the rotation, you should use the NPV as the loan amount. The payment function calculates a payment that is the same as the equivalent annual income.

Land expectation value (LEV)

The net present value of the tree farm is $2,713/acre. The future value at 4% interest rate and 35 years is therefore

$$2{,}713\ (1.04)^{35} = 10{,}706$$

The net present value of this and all other future rotations, given the same production figures and costs, would be

$$LEV = \frac{10{,}706}{(1.04)^{35} - 1} = 3634$$

If the production figures, cost estimates, and prices are correct, the land is worth $3,634/acre when trees are grown. If you have already calculated an EAI as in the example above, the LEV may be simply calculated from the EAI and the discount rate (i):

$$LEV = \frac{145}{0.04} = 3625$$

Slight differences are due to rounding errors.

Spreadsheet available

A computer spreadsheet with the above tables and other sample calculations for a tree farm in Hawaii is available for downloading from the CTAHR web site, <http://www2.ctahr.hawaii.edu/oc/freepubs/spreads>. The spreadsheet is written in Microsoft Excel format. The figures given in the spreadsheet are intended to serve as an example only. You must add your own data and projections to come up with reasonable predictions for your own tree farm.

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Appendix 1. Sample costs used in financial calculations for a small teak plantation (10–50 acres) on the Hamakua coast of Hawaii.

Establishment		
Management plan	50	$/acre
Site preparation	200	$/acre
Seedlings	2	$/seedling
No. seedlings	435	seedlings/acre
Planting	150	$/acre
Fencing	500	$/acre
Herbicide application	160	$/acre
Second herbicide application	160	$/acre
Fertilizer application	165	$/acre
Operations	$/acre/year	
Weed control up to year 4	160	
Fertilizer up to year 4	70	
Maintenance starting year 5	25	
Management costs	0	
Land costs	0	
Property taxes	0	

Appendix 2. Hypothetical yields of a teak plantation on the Hamakua coast of Hawaii. Yields represent total volume of the plantation if clearcut in the given year.

Age	Yield (mbf/acre)
20	6.2
25	11.6
30	18.1
35	23.9
40	28.5
45	31.0
50	32.5
55	33.5
60	34.2

Thinning revenue	
No. stems cut at year 5	218 stems/acre
Price/stem at year 5	$0
No. stems cut at year 15	109 stems/acre
Net price/stem at year 15	$1