Forest Research Group

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Biological Growth Rates and Rates of Return

Biological growth is frequently touted as a unique characteristic of timberland as an investment asset. It is often assumed by people new to the asset class that faster growing trees must provide a higher rate of return than slower growing trees and, therefore, must be a better investment. While faster growing trees may in fact produce a higher rate of return, the biological growth rate is not the same as the rate of return on the investment. And the difference in the rates of return may not be as great as the difference in the growth rates.

Trees grow, and as they grow they add volume. More volume means more value. Timberland can increase in value even if land and timber prices remain constant because the volume of standing timber will increase. This volume increase can help timberland hold its value even if land and timber prices are declining. If timber is harvested at the rate the trees are growing, timberland can generate income with no loss in value to the asset.

Growth varies according to a wide range of variables, including soils, species, silvicultural treatments and stand age. Biological growth is not constant in the life of a tree. Young trees grow much faster than older trees. But very young trees put most of their growth into height, adding little volume. Older trees will put less growth into height and more into diameter, which contributes far more volume to the stand. Very old trees will grow very slowly, with most of their growth in diameter rather than height.

Foresters often express biological growth in terms of the volume produced on an acre in a year. That volume is usually stated as an average across the forest property. For example, northern hardwood forests will produce from a quarter of a cord to a half a cord per acre per year. Ideal conditions might push the growth to ¾ of a cord per year, especially towards the southern end of this forest type's range. Southern pine plantations will produce 3 to 12 tons per acre per year, depending largely on the intensity of silvicultural treatments applied..

But what is the ***rate*** of growth? That depends in part on the volume already standing in the forest. This is much like knowing that a stock dividend is $2/share, but we need to know what the stock is worth before we can determine the return on the stock.

Northern Hardwood Growth Rates

Stocking levels in the Northeast are often expressed in terms of cords per acre, a figure that includes both pulpwood and sawtimber combined. At ten cords per acre, most of the standing timber is not harvestable because it is in buffers along streams or roads or around clearcuts or because it is not mature. The trees in these buffers can probably be cut *someday*, once other trees fill in the clearcuts or the stream and roadside buffers stabilize after a harvest, but most of them cannot be cut *now*. These forests are full of young trees that are growing fast, but not producing much volume.

Table 1. Northern Hardwood Growth Rate Calculations

	Low Stocking Level		Medium Stocking Level		High Stocking Level	
Cords/Acre/Year	0.25	0.50	0.25	0.50	0.25	0.50
Average Cords/Acre	15	15	20	20	25	25
Growth Rate	1.67%	3.33%	1.25%	2.50%	1.00%	2.00%

15 cords per acre is on the lower end of the stocking range for investment grade forests in the Northeast. In contrast, 25 cords per acre is a relatively high stocking level in the region. Above that point, the growth rate begins to fall off because the trees are crowded.

Table 1 shows a reasonable range of growth rates that might be calculated for a northern hardwood forest based on the beginning stocking level. These are simplistic calculations, dividing the volume of growth per acre per year by the starting volume:

$$GrowthRate = \frac{AverageGrowthPerAcrePerYear}{StartingVolume}$$

A more sophisticated analysis would use a growth and yield model. Such models exist for most important commercial timber types in each region. The most commonly used models in the Northeast are NE-Twigs and Fiber, both developed by the USDA Forest Service. These models can develop a more precise growth rate based on stand stocking, age and species composition.

Table 1 gives us a range of 1 to 3.3 percent per year for a northern hardwood forest growth rate. But the rate of growth ***is not*** the same as the rate of return. It is important to distinguish between the biological volume growth rate and the contribution that volume growth makes to the return on the investment.

Table 2 shows how the biological growth rate contributes to the return on a hypothetical northern hardwood investment. We assume a 100,000 acre investment purchased at $250/acre for a total investment of $25 million. (Recent large timberland transactions in Maine suggest this hypothetical transaction is a real bargain.)

Table 2. Contribution of Northern Hardwood Biological Growth Rate to Investment Return

Acres	Given	100,000
$/Acre Purchase Price	Given	$250
Purchase price	Calc	$25,000,000
Timber Value	Given	$40,000,000
% of Gross Timber Value	Calc	62.5%
Timber Volume Growth Rate	Given	2.00%
Timber Value Growth	Calc	$800,000
Increase in Value	Calc	3.20%

We then assume the biological growth rate is 2%. This is a level that can be achieved under all three stocking levels shown in Table 1.

The gross timber value is $40 million. In the Northeast, it is common for the total value of the timber on the property to exceed the purchase price on large tracts. This sounds strange, but it happens because the timber inventory cannot be physically or economically liquidated over a short time period. Since it would take years to remove all the timber, the purchase price actually reflects a discount due to the time it would take to accomplish this.

In this example, the purchase price is 62.5% of the gross timber value, a reasonable discount for a property of this size and a number that gives us nice round numbers for our analysis.

Since the timber volume growth rate is 2%, we will have 2% more volume on the forest next year. We assume that it will be worth 2% more, or $0.8 million.

[In reality, the larger trees will probably have contributed a larger share of this additional volume, which means the sawtimber trees will have added more volume than the pulpwood trees. With more of the volume being added to the more valuable trees, we could make a case that the value of the timber will actually increase at a greater rate than the volume. But we will ignore this for now.]

If the forest has gained $0.8 million in value, that is a 3.2% return on our $25 million investment. In this case, the rate of return on the investment is higher than the biological growth rate.

Remember that this increase in value is only one component of the return on the investment. It does not include any change in timber prices or in the value of the land, nor does it include the impact of timber harvesting.

Southern Pine Growth Rates

Table 3 shows the growth rate calculations for a typical southern pine plantation. The volumes that can be generated depend largely on the intensity of silvicultural treatments applied. A minimum level of site preparation will produce about 3 tons per acre per year in a plantation. Intensive treatments can push volumes up over 10 tons per acre per year.

The table shows that we can expect southern pine growth rates that are 5-10 times higher than northern hardwood growth rates.

But while the biological growth rates are much higher than those for northern hardwoods, the contribution to the return on investment is affected by the investment cost. Table 4 shows how the biological growth rates contribute to the investment return on the southern pine plantation.

Again we assume a 100,000 acre tract, but here in the South we will have to pay $800 to $1,200 per acre for good pine lands. About half the value of the purchase price (assume $1,000/acre for this example) is the value of the timber. This is a number that varies with the age-class distribution of the property and commonly ranges between 30% and 70%.

We assume we will grow 7 tons of wood per acre per year which falls in the middle of the range shown in Table 3. 7 tons per acre per year gives us a growth rate of 14% which in turns equates to $7 million in added timber value per year. The $7 million increase in value due to biological growth amounts to a 7% return on our initial investment of $100 million.

Table 3. Southern Pine Plantation Growth Rate Calculations

Tons/Acre/Year	4	6	8	10
Average Volume on Merch Acres	50	50	50	50
Growth Rate	8%	12%	16%	20%

Table 4. Contribution of Southern Pine Plantation Biological Growth Rate to Investment Return

Acres		100,000
$/Acre Purchase Price		$1,000
Purchase price		$100,000,000
Land Value	35%	$35,000,000
Premerchantable Timber Value	15%	$15,000,000
Merchantable Timber Value	50%	$50,000,000
Timber Volume Growth Rate		14.00%
Timber Value Growth		$7,000,000
Increase in Value		7.00%

Comparison

Our analysis shows that biological growth rates do not translate directly to investment return rates. Our hypothetical southern pine forest has an average growth rate that is seven times greater than the average growth rate of our northern hardwood forest, but the annual increase in value is just slightly more than twice as much (7.0% vs. 3.2%).

Obviously in our example, the higher growth rates of the southern pine plantation were high enough to provide higher returns than the slower-growing northern hardwood forest, but the return difference was not as great as the growth rates suggest.

Notes

A southern pine plantation with a higher proportion of premerchantable age classes will have a lower increase in value over the near term because the increase in merchantable volume will be less. This will change at some time in the future as the large acreages of permerchantable stands move into the merchantable years. Of course, the purchase price for such a property might be a little less, so the investment basis would be a little less, so the difference in returns might be a little less....

This analysis has also ignored in-growth. As trees grow, they add volume. But at times, they also change product classes. A southern pine pulpwood tree might be valued at $10/ton, but a chip n saw tree just an inch larger might be valued at $25/ton, a jump in value of 150%. The chip n saw tree will jump to $45 or $50/ton when it hits sawtimber.

Unfortunately, not all the trees in any given age class are the same size. Not all the trees in a 25-year-old southern pine stand are sawtimber trees. In fact, most growth and yield analyses show that sawtimber makes up 20-50% of the volume in stands at rotation age.

Northern hardwood stands have even more exciting in-growth numbers. Hardwood pulpwood might sell for $3/ton. Sugar maple sawtimber might sell for $100 to $300/ton, an increase of 3000% to 10000%! The downside is that you might have to wait 60-70 years for that sugar maple pulp tree to growth to sawtimber size.

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