Growth Projection and Discounted Cash Flow as Decision Tools for Loblolly Pine Silviculture

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Abstract

A study of the effects of competition control alternatives on loblolly pine growth was installed at the Appomattox-Buckingham State Forest between July 2005 and August 2007. The results from that test were described in Research Report 130. The observed age 10 diameter distributions were used to initialize the Ptaeda4.1 growth and yield model developed by the Virginia Tech Forest Modeling Research Cooperative, and stand growth was projected through a 40-year rotation. Those projected yields were used to calculate present values (PV – at time of stand establishment) of different scenarios comparing alternate rates of return (interest rate - ARR), rotation lengths, hardwood competition levels, thinning strategies, product prices, site qualities and establishment wait times. The results provide insights into the relative significance of these variables and their impacts on financial returns from forestry activities. Some of these – alternate rate of return, expected product pricing and rotation length – are subjective and depend on the investor's assumptions. Others – hardwood control, thinning strategy / timing and site productivity (as influenced by the choice of seedling genetics) – are silvicultural choices. Of these, the impacts on PV (in descending order) rank: (1) hardwood competition > (2) site productivity (i.e. seedling genetics) > (3) thinning strategy > (4) a one-year delay in establishment.

- A higher ARR results in a reduced present value of future cash flows and shorter optimum rotation length.
- Any revenue that can be captured before final rotation or any silvicultural activity that shortens the rotation will increase PV.
- Sites with less hardwood competition produce more value.
- Thinning increases the maximum PV and increases the financially optimum rotation length, and the gains are greater at a lower ARR.
- "Pulpwood" markets generate lower present values and favor shorter rotations. Thinning is important to capture the added value in a "sawtimber" market.
- More productive sites – whether due to inherent attributes or improved seedling genetics – generate more value.

- Assuming *no impact* on productivity / value, the cost of waiting one year to establish a new stand is minimal.

Methods

In the summer of 2005, the VDOF collaborated with BASF Corporation's Market Development Specialist Harold Quicke (now with Bayer CropScience) and Dwight Lauer of Silvics Analytic on the installation of a test to compare the effects of various chemical weed control strategies on loblolly pine growth. The test was installed on the Appomattox-Buckingham State Forest. A detailed description of the study installation, measurements and results through age 10 is presented in Research Report #130.

The observed pine growth data from that study can be used to project and compare longer-term financial implications of different scenarios. To that end, the diameter distributions from the untreated, released and site-prepared (October 1 application date) plots at age 10 were used as inputs to initialize the Ptaeda4.1 growth-and-yield model developed by the Virginia Tech Forest Modeling Research Cooperative. The model was then use to "grow" the observed stand forward through a simulated 40-year rotation. Because the model provides estimates of green tons per acre in pulpwood, chip-n-saw and sawtimber product classes, we were able to apply pricing assumptions for those product classes to calculate total stand value annually.

While it may be interesting to consider the actual returns (dollars per acre) at some future harvest date, that is not a fair basis for comparison among alternatives. We all know that (1) inflation causes each dollar to be worth less with each passing year and (2) for landowners viewing their loblolly pine forest as an investment there is some threshold annual rate of return (percentage) they will expect to achieve. Because the timing of thinning, final harvest and other management activities differs under the scenarios presented, it is valid only to compare cash flows if they are adjusted to value them at the same point in time. For purposes of this exercise, that time will be at stand establishment (i.e. at planting – age zero). So, for example, this would ensure that thinning revenue at age 18 and harvest revenue at age 40 would each be valued on the same basis – in terms of dollars at time of planting.

Only one formula is required for the calculations in this report. It is the discounting formula:

- $V_0 = V_n / (1+i)^n$
  - where
  - V_0 = present value (PV);
  - V_n = future value;
  - n = number of years between V_0 and V_n, and
  - i = the alternate rate of return, or interest rate.

Assumptions common to all of the projections in the following pages include:

- well-drained soils;
- Piedmont physiographic region;

- chop / burn debris management;
- improved seedling genetics;
- minimum dbh and top diameters for pulpwood, chip-n-saw and sawtimber are five and four; eight and six, and 12 and eight inches, respectively;
- topwood from chip-n-saw and sawtimber added to pulpwood category;
- pine volumes in green tons, and prices in dollars per green ton;
- no hardwood fiber included in harvested values, and
- all projected values are in dollars per acre at the time of planting.

Unless noted in the individual sections below, other assumptions include:

- six percent alternate rate of return;
- site index of 65;
- hardwood competition comprising two percent, five percent and 15 percent of the stand basal area after site preparation, age two release, and no competition control scenarios, respectively;
- pulpwood, chip-n-saw and sawtimber prices (from TimberMart South, 3rd Quarter 2016) of $14.35, $18.02, and $20.31 per green ton, respectively, and
- no thinning.

No other cash flows (expenditures or revenues) are included in these calculations. Expenditures, such as planting, competition control or fertilization cost and revenues like hunting leases, would all have to be evaluated for a complete analysis.

Important Notes: This is not a complete discounted cash flow analysis. The results presented here are examples intended to provide insights comparing long-term outputs from different scenarios. Although these results are based on observed growth data, the wide range of conditions and natural occurrences that impact individual sites; the many assumptions that go into financial calculations, and the inexact nature of growth models make it certain that individual landowners' results will vary – possibly significantly – from the estimates derived here. For example, just changing the alternate rate of return in the discounting formula by one or two percentage points will drastically change the resulting values. Therefore, these should be used as decision-making aids and food for thought to compare and chose among alternatives but should *never* be taken as a guarantee of any particular financial or stand development outcome.

Alternate Rate of Return (ARR)

- **A higher alternate rate of return results in a reduced present value of future cash flows and shorter optimum rotation length.**

The choice of this variable is difficult, yet it can have a greater effect on the investment decision than any other assumption. To be financially viable, a pine plantation investment has to generate income sufficient to (1) offset the anticipated impact of inflation over time and (2) equal – or preferably exceed – the income the landowner would expect to receive from some alternative investment, such as real estate or a stock or mutual fund. Inflation has averaged about 1.5 percent annually over the last decade, and is approximately two percent at the time of this report. The landowner's threshold for additional income depends on what other investment options could be available; how much they would return, and how much comparative risk the investor perceives. The long investment horizon in forestry may demand a higher rate of return to justify the increased risk. Many forestry investors use alternate rates of return in the four percent to eight percent range. For example, consider a scenario using the assumptions on pages two and three with a site preparation hardwood control treatment. At the recent average inflation rate of 1.5 percent, the fiber produced at final harvest is valued (using the discounting formula on page 2) at $2,163 at time of planting. At the current two percent inflation rate, that PV is $1,855. So, a change in ARR of just 0.5 percent affects the present value by $308. Next, assume that when the landowner considers goals for returns on invested capital the interest rate threshold rises to four percent, six percent or eight percent. The impacts get substantially larger (Figure 1), and PVs decline to $1,062, $686 and $473, respectively.

Notice that the choice of interest rate also affects the financially optimum rotation length; as ARR increases from 1.5 percent to eight percent, the age at which PV peaks decreases from 33 to 18. Properly timing silvicultural activities is another important consideration for landowners focused on maximizing financial returns.

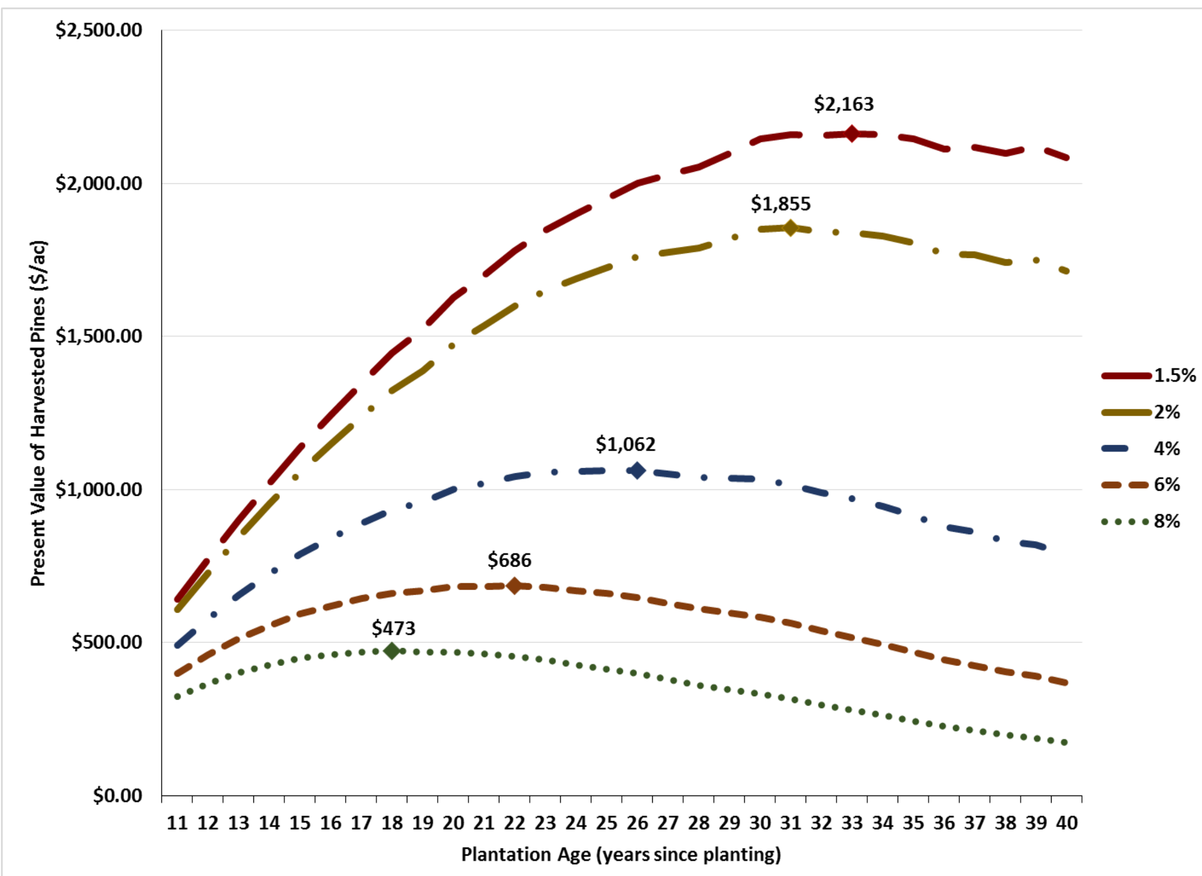

Figure 1. Value ($/ac) at time of stand establishment of a loblolly pine stand with site preparation hardwood control between ages 11 and 40 assuming varying alternate rates of return (i.e. interest rate or discount rate). Maximum values for each curve are indicated by the labeled data points.

Rotation Length

- **Time is money.**

In the discounting formula, notice that time (n, years) is in the denominator, and it is an exponent. Dividing any future cash flow amount by a value greater than one automatically reduces the result (i.e. the discounted – or present – value). As investment duration (stand rotation length) increases, PV of a given revenue decreases.

For example, a $100 income from a thinning operation 15 years from now using a six percent interest rate would be worth $100/(1.06)^{15}$ or $41.73 today. Waiting three years to thin at age 18 would reduce the PV of that $100 to $35.03, so that wait would need to result in a PV gain of $6.70 to be justified. On the other hand, waiting 30 years to receive the same $100 in a final harvest would reduce the PV to $100/(1.06)^{30}$ or $17.41. Any revenue that can be captured before final rotation or any silvicultural activity that shortens the rotation will increase PV.

Looking at this another way, a return of $2,500 per acre at age 30 would be worth (using the same formula and six percent rate) $435.28 today. It would take only $1,043.18 earned at age 15 to equal the same amount in today's dollars. And shortening the rotation by just three years (to 27) would increase that PV to $518.42.

Hardwood Competition Level

- **Sites with less hardwood competition produce more value.**

It is well-documented that loblolly pine productivity can be increased by removing hardwood competitors. For example, the results from Research Report 130 showed that removing hardwoods before planting (with the site preparation treatment) doubled pine yield compared to leaving the hardwoods in the stand. Along with the added growth comes a shift in tree sizes that puts more stems in the more valuable sawtimber product class. As a result, the peak PVs in stands with no hardwood control , age two release and site preparation are projected to be $388, $576 and $686, respectively, and occur 24, 23 and 22 years after planting (Figure 2). That combination of higher revenue and shorter rotation length offered by earlier competition control is particularly attractive.

Research has indicated that without competition control pine plantations in the Piedmont of Virginia can contain as much as 75 percent of their stand basal area in hardwoods. If we vary the hardwood competition level assumed in the model, it becomes clear that the amount of competition present has a large effect on the value of the pine crop; the optimum time to harvest, and the value added by competition control treatments (Figure 3). Increasing the hardwood level from 15 percent to 25 percent, 50 percent and 75 percent decreases the value of the stand by as much as $255 per acre. And because more suppressed pines are slower to grow into more valuable product classes, the financially optimum harvest age becomes shorter. In essence, at high hardwood levels, it is better to start over early than to waste years or decades waiting for a small amount of chip-n-saw or sawtimber to develop. If more hardwoods are present, the pine growth (and value) benefits from controlling them become greater.

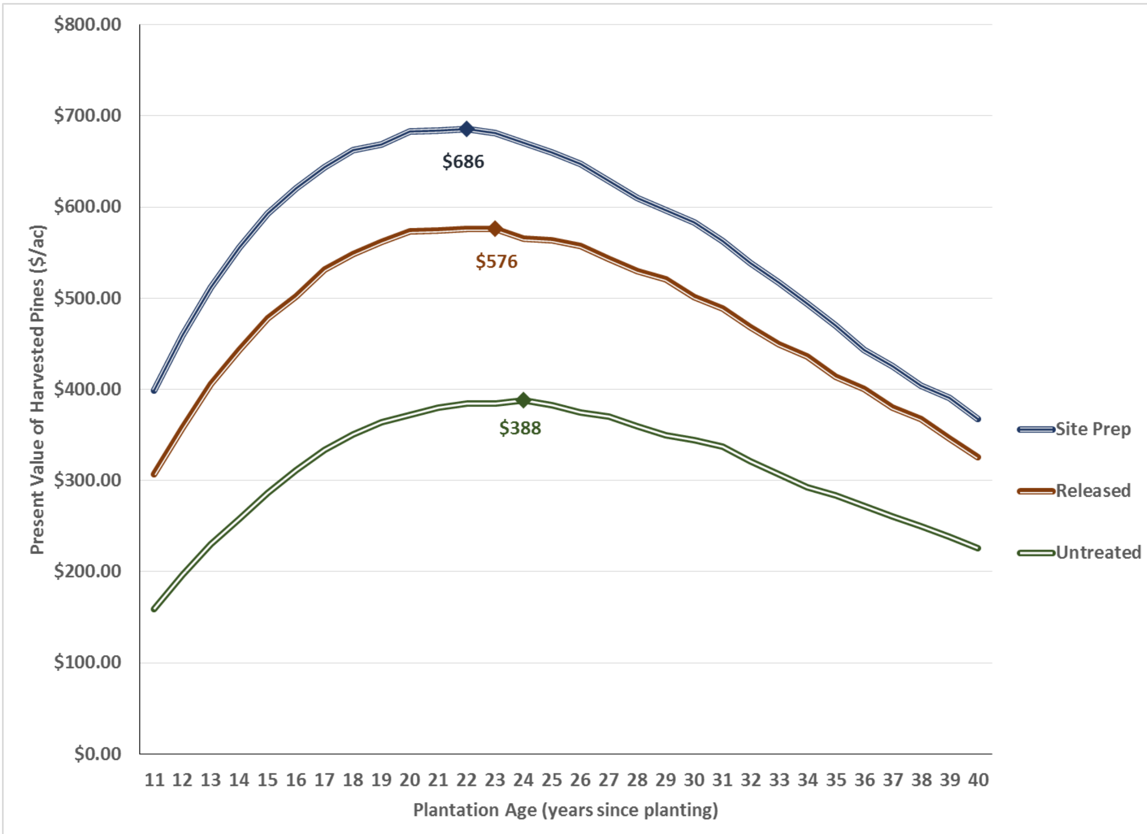

Figure 2. Value ($/ac, using a six percent ARR) at time of stand establishment of a loblolly pine stand between ages 11 and 40 assuming different hardwood competition control strategies. Maximum values for each curve are indicated by the labeled data points.

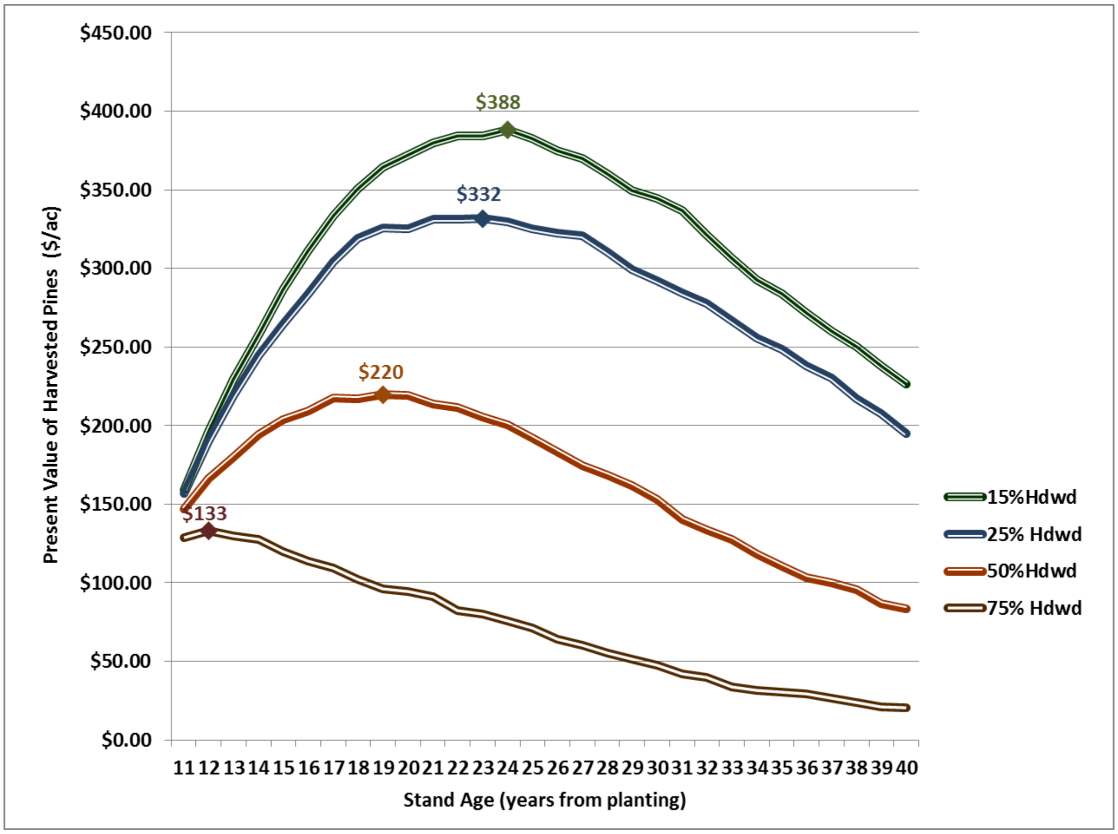

Figure 3. Value ($/ac, using a six percent ARR) at time of stand establishment of a loblolly pine stand between ages 11 and 40 assuming different hardwood competition intensities (percentage of total basal area in hardwoods). Maximum values for each curve are indicated by the labeled data points.

Thinning Strategy

- **Thinning increases the maximum present value and increases the financially optimum rotation length, and the gains are greater at a lower alternate rate of return.**

Without thinning, loblolly pine stands will reach a point where intraspecific competition (among the surviving pine trees) becomes limiting and growth and value decline. Thinning reduces stand density and maintains the growth rate of the residual stand. To look at these effects, the model was used to simulate a thinning imposed in the year when the basal area in the stand reaches approximately 150 ft^2/ac. In the case of our site preparation scenario, this occurs at age 14. The results from applying this thinning at alternate rates of return of four percent and eight percent are shown in Figure 4. With thinning, the maximum PV increases by between $25 and $110 per acre as interest rate declines from eight percent to four percent. Again, choosing a lower ARR makes present values more attractive. Thinning also extends the financially optimum rotation length between five years and nine years, depending on interest rate.

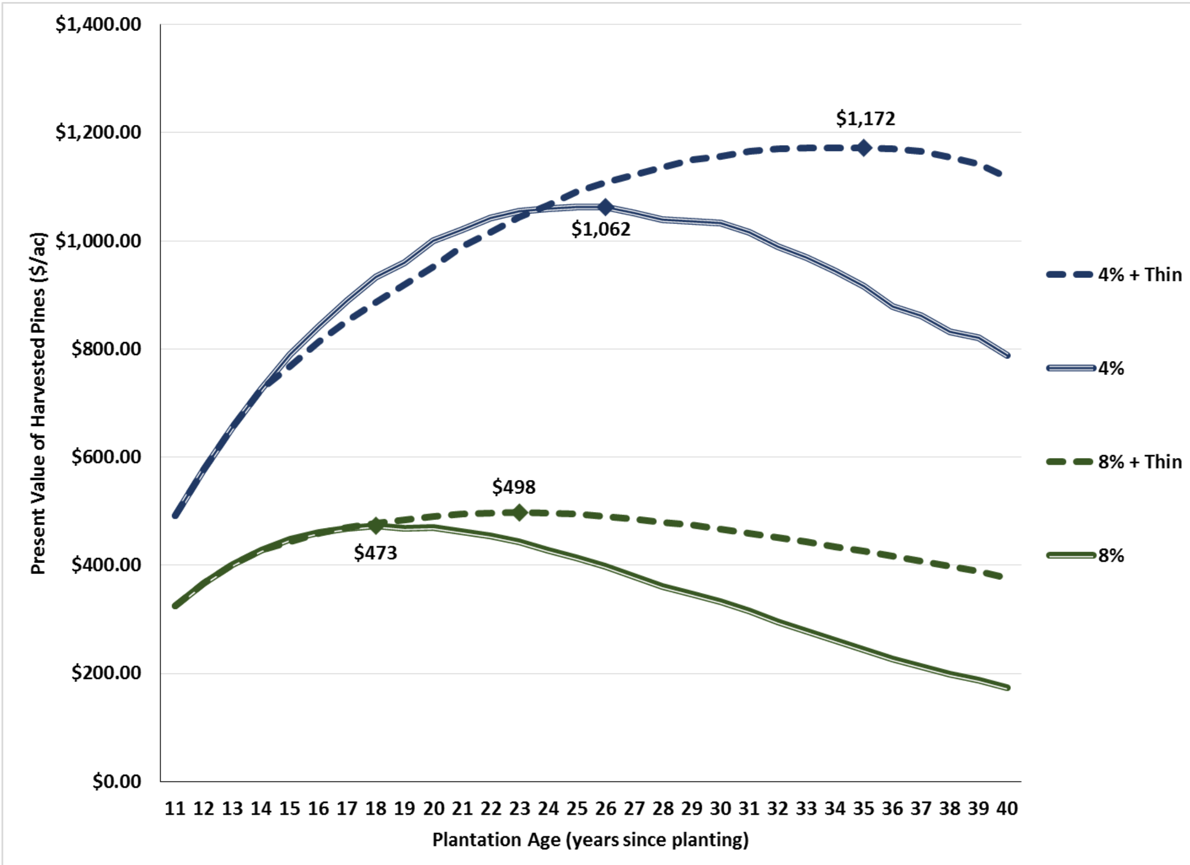

Figure 4. Value ($/ac) at time of stand establishment of a loblolly pine stand between ages 11 and 40 assuming varying alternate rates of return with and without thinning to a residual basal area of 70 ft^2/ac in the year the total stand basal area approaches 150 ft^2/ac. Peak values for each curve are indicated by the labeled data points.

Product Pricing

- **Markets are unpredictable yet critical components of financial analysis. Those weighted toward higher pulpwood prices generate lower present values and favor shorter rotations.**

Past markets have priced sawtimber considerably higher than pulpwood; while recent markets tend to favor pulpwood. To get an indication of how this might affect silvicultural decisions, consider our base case site preparation scenario with a thinning decision under two alternative pricing scenarios – pulpwood, chip-n-saw and sawtimber priced at $15, $18 and $22, respectively, per green ton (a "pulpwood" market) versus $5, $20 and $40 per green ton (a "sawtimber" market). As one might expect, stand values are higher with a "sawtimber" market – but thinning becomes very important to capture that added value (Figure 5). In the "pulpwood" scenario, thinning increases stand value by $74. In the "sawtimber" case, it adds $247. Without thinning the difference between the two pricing scenarios is only $11; while with thinning there is a $184 difference. This is another difficult-to-predict variable, but the market for different wood products in the future can be another key driver in choosing silvicultural regimes.

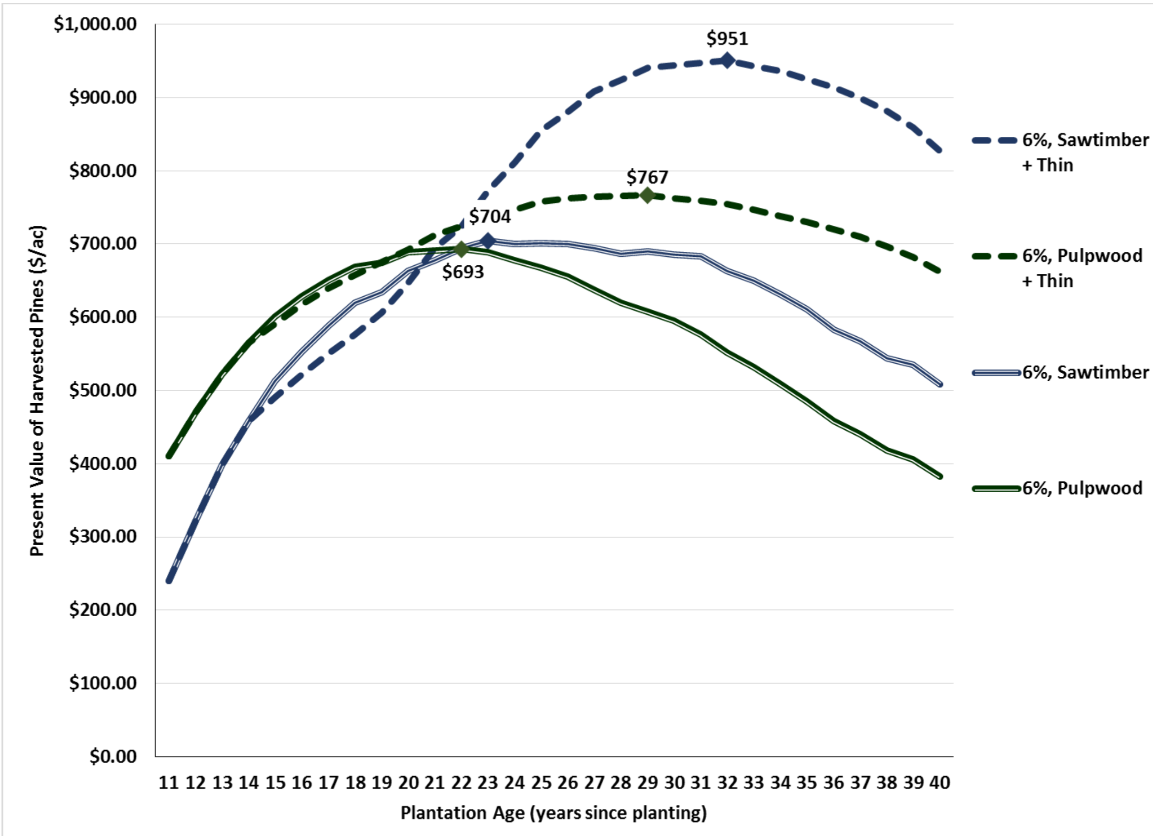

Figure 5. Value ($/ac) at time of stand establishment of a loblolly pine stand between ages 11 and 40 comparing "pulpwood" and "sawtimber" product pricing scenarios with and without thinning to a residual basal area of 70 ft^2/ac in the year the total stand basal area approaches 150 ft^2/ac. Peak values for each curve are indicated by the labeled data points.

Site Productivity

- **More productive sites generate more value**

More productive sites (either due to soil nutrients, moisture availability, local climate, improved tree genetics or other factors) grow trees larger and more rapidly than less productive sites. Given the preceding discussions about rotation length and product pricing, it is not surprising that financial values are larger on such sites. The shortened rotation to a given product objective results in higher PVs by around $120 per acre for every 10-foot increase in site index.

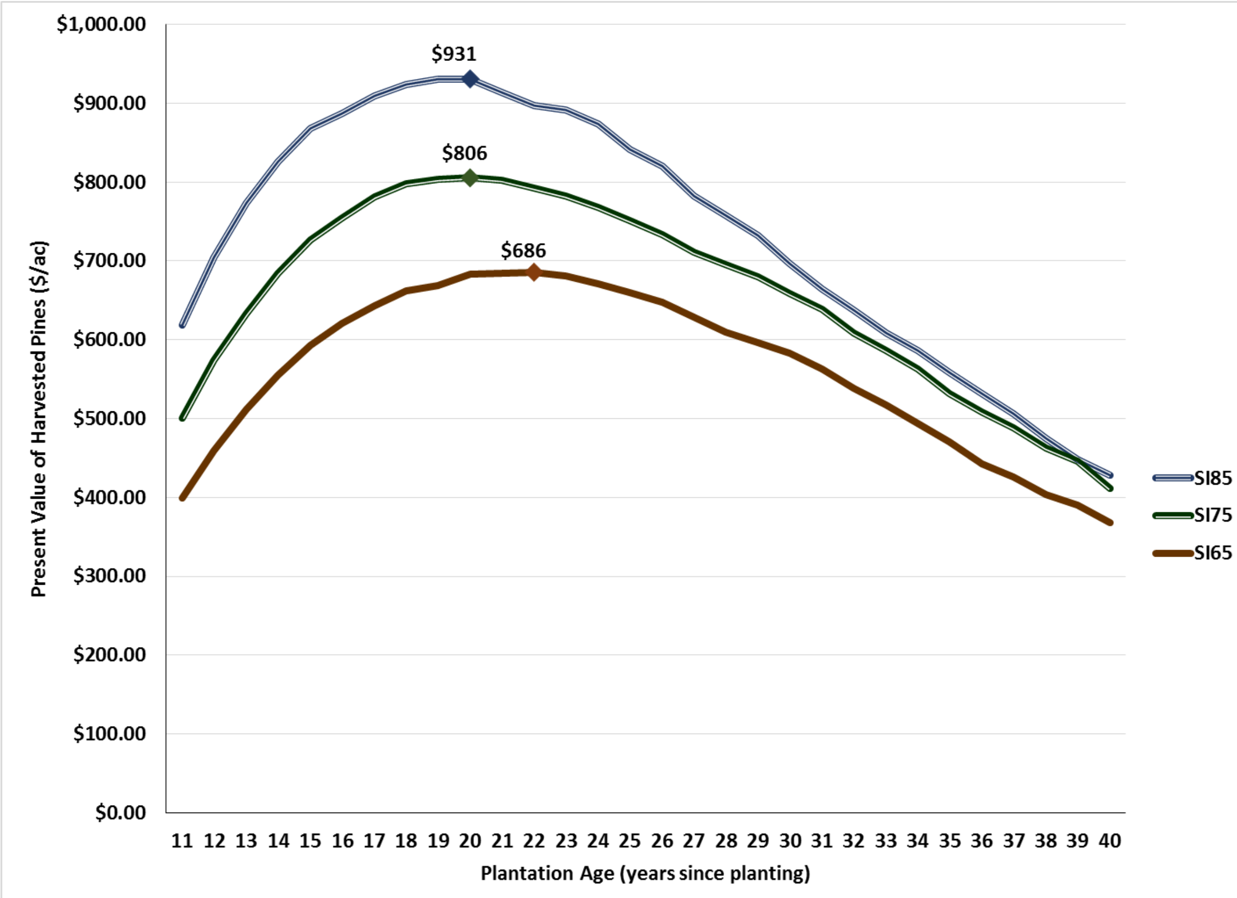

Figure 6. Value ($/ac) at time of stand establishment of a loblolly pine stand between ages 11 and 40 growing on site with different productive potential (site index). Peak values for each curve are indicated by the labeled data points.

One-Year Layout

- **Assuming *no impact* on productivity / value, the cost of waiting one year to establish a new stand is minimal. If waiting *increases* pine productivity / value by even a modest amount, the one-year layout is a viable alternative.**

This decision most often arises when a harvest has been completed in late spring or summer. Since competing vegetation may not fully emerge in time to be effectively controlled with a fall site preparation treatment, a choice must be made between two scenarios: (a) plant the next pine stand at the first opportunity the following season without site preparation in the expectation of releasing the stand after one or two growing seasons, or b) deferring planting and waiting until the end of the next growing season to conduct site preparation before planting the following spring. The tradeoff can be meaningful if competing vegetation is anticipated that could be difficult to control with a release treatment. Site preparation generally affords the latitude of using herbicide products and / or rates that may not be safe over the planted pines but would provide more complete and longer-lasting control of competing woody and herbaceous plants (particularly volunteer pines).

One way to weigh this decision using financial data would be to assume that there is zero benefit from waiting to do site preparation. This is a conservative assumption, but it would mean that one would achieve exactly the same growth (and hence the same value) under either scenario – just one year later with scenario (b). Therefore, the only "cost" or value lost by waiting one year would be the difference between the stand value discounted for the projected rotation length and that same value discounted for one *additional* year. The trends in this additional cost over the 40-year projection period for thinned and unthinned site preparation options appear in Figure 7. The largest impact of the one-year wait under this analysis occurs under a thinned and site-prepared scenario and amounts to $41.32. If waiting allows the landowner to practice a management regime that increases PV by approximately $40 or more, the layout is financially justified.

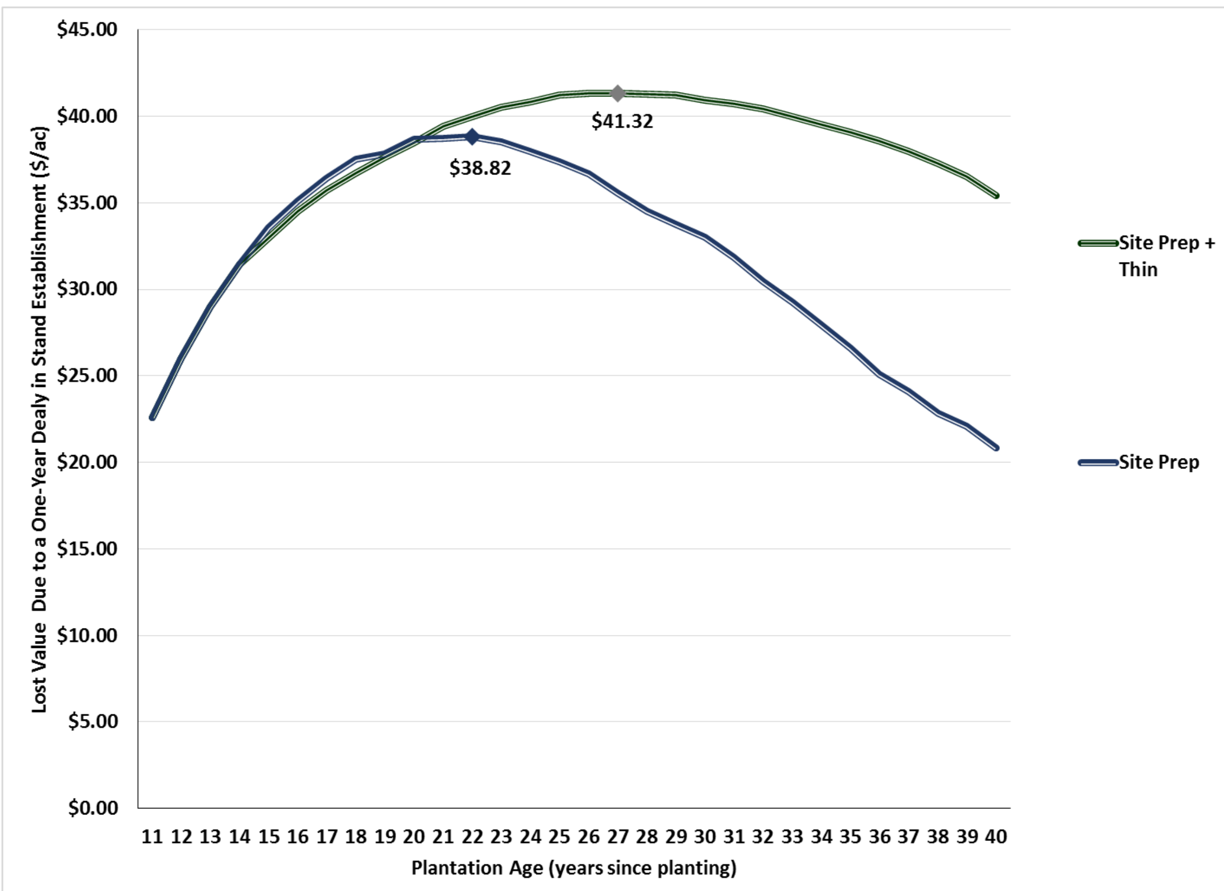

Figure 7. Value (PV) lost with a one-year delay in stand establishment ($/ac, using a six percent ARR) of a loblolly pine stand between ages 11 and 40. Peak values for each curve are indicated by the labeled data points.

Discussion

The impacts of all of the variables discussed – alternate rate of return, hardwood competition control and intensity, thinning, product pricing, site quality and one-year layout – are summarized in Table 1.

Table 1. Maximum present value (PV) and optimum financial rotation length (i.e the stand age at which maximum PV occurs) of loblolly pine plantations under various scenarios.

Alternate Rate of Return

1.50%	2%	4%	6%	8%
$2,163 / 33	$1,855 / 31	$1,062 / 26	$686 / 22	$473 / 18

Hardwood Control Strategy (assuming a 15% pre-treatment hardwood basal area)

No Control	Age 2 Release	Pre-Plant Site Prep
$388 / 24	$576 / 23	$686 / 22

Hardwood Competition Intensity (as a percentage of total stand basal area)

15%	25%	50%	75%
$388 / 24	$332 / 23	$220 / 19	$133 / 12

Thinning Options

No Thin - 4% ARR	Thin - 4% ARR	No Thin - 8% ARR	Thin - 8% ARR
$1,062 / 26	$1,172 / 35	$473 / 18	$498 / 23

Product Pricing / Market Conditions

Pulpwood 6% ARR	Sawtimber 6% ARR	Pulpwood 6% ARR + Thin	Sawtimber 6% ARR + Thin
$693 / 22	$704 / 23	$767 / 29	$ 951 / 32

Site Quality

SI 65	SI 75	SI 85
$686 / 22	$806 / 20	$931 / 20

Cost (Lost Value in terms of PV) of One-Year Layout Prior to Stand Establishment

Site Prep	Site Prep + Thin
$38.82 / 22	$41.32 / 27

Growth projections and financial analyses can be used to help guide silvicultural decisions. Although the actual yields and values are very difficult to predict, the relative differences between projected scenarios are helpful in choosing options more likely to maximize value – if that is a key objective for the landowner in question. Under the conditions in the study observed through age 10, the following are apparent:

A higher alternate rate of return results in a reduced PV of future cash flows and shorter optimum rotation length. Within the four percent to eight percent range used by many forestry investors, this choice can change present value of future revenues by $589 per acre and optimum rotation length by eight years.

In this case, time really is money. Deciding when to conduct a final harvest (i.e. rotation length) affects PV by changing the discounting period. If a silvicultural system could be identified to produce the same volume / value in 27 years instead of 30, the increase in PV amounts to more than $518 per acre.

Sites with less hardwood competition produce more value. In this study, plots with hardwood stems comprising 15 percent, five percent and two percent of the total stand basal area are projected to be valued at $388, $576 and $686, respectively, and the rotation length is lowered from 24 to 23 and 22 years after planting. Hardwood levels in central Virginia can exceed 70 percent of stand basal area on some sites. Increasing projected hardwood competition to 25 percent, 50 percent and 75 percent decreases the value of the stand by as much as $255 per acre. At higher hardwood levels, the optimum rotation decreases because the trees never grow into more valuable size classes (and, hence, added time does not increase value).

Thinning increases the maximum present value and increases the financially optimum rotation length, and the gains are greater at a lower alternate rate of return. Maximum PV increases by between $25 per acre and $110 per acre with thinning depending on the choice of alternate rate of return.

Product markets weighted toward higher pulpwood prices generate lower present values and favor shorter rotations. PVs are higher in a "sawtimber" market. In a pulpwood market, thinning increases stand value by $74, while in a sawtimber scenario it adds $247. And thinning becomes important to capture that added value. Without thinning, the difference between the two pricing scenarios is only $11, while with thinning there is a $184 difference.

More productive plantations (either due to soil nutrients, moisture availability, local climate, improved tree genetics, or other factors) grow trees larger and more rapidly than less productive sites. The resulting accelerated rotation to a given product objective results in higher PVs by around $120 per acre for every 10-foot increase in site index.

Assuming *no impact* on productivity / value, the cost of waiting one year to establish a new stand is minimal. If waiting *increases* pine productivity / value by even a modest amount, the one-year layout is most likely warranted. Under that assumption, the cost of waiting one year would be the difference between the PV discounted for the projected rotation length and that same PV discounted for one *additional* year. If waiting allows the landowner to practice a management regime that increases present value by approximately $40 or more, the layout is financially justified.

Some of these assumptions – alternate rate of return, expected product pricing and rotation length – are subjective assumptions that can be varied by the investor. Others meanwhile – hardwood control, thinning strategy/timing and site quality (as affected by the choice of seedling genetics) – can be influenced directly by silvicultural choices. Of these activities, the impacts on PV (in descending order) would rank: (1) hardwood competition ($298 - $553 per acre) > (2) site quality [(i.e. seedling genetics), $120-$125 per acre)] > (3) thinning strategy ($25 - $110 per acre) > (4) one-year delay ($39 - $41 per acre).

Tools are available to project growth and productivity of loblolly pine sites across Virginia, and these same discounted cash flow approaches can be used to compare possible financial outcomes of any combination of the variables examined here. For a landowner with financial returns as a high priority for loblolly pine management, these could be useful tools for helping to decide on the type and timing of silvicultural activities.