Economic Returns Model for Silvicultural Investments in Young Hardwood Stands

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Abstract

The NC State Hardwood Research Cooperative has been investigating the productivity responses of very young (ages 1 to 10 years) even-aged hardwood stands to silvicultural treatments such as fertilization, herbicide release, individual-tree release, and various methods of stocking control. These treatments have yielded large productivity increases in treated research plots, demonstrating the potential for faster timber growth, higher quality, and shorter rotations. In determining the extent to which these productivity increases may justify investment in various silvicultural treatments, we have developed hardwood and mixed pine-hardwood management scenarios representing productivity increases of up to 33%. Timber revenues have been estimated and internal rates of return calculated for a common 60-year investment period. Next, we have compared rates of return across various management intensities and evaluated potential investments in silvicultural treatments that would achieve rates of return that are higher than or equal to returns in untreated stands. Results indicate that there are significant opportunities for economic gains given the assumed productivity increases. Acceptable investments would readily pay for treatments such as fertilization, herbaceous release, and stocking control.

Keywords: hardwood silviculture, hardwood economics

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Introduction

Despite covering the majority of southern forestland, hardwoods continue to be grown primarily in natural stands and managed with low intensity, indicating that investment in growing hardwoods has been relatively low, particularly in comparison with intensively managed pine plantations. One reason is that hardwood growth increases resulting from active management have been small in comparison with unmanaged stands. Another reason is that hardwoods were in ample supply, and management returns were generally insufficient to justify intensive cultural treatments. Increasing hardwood utilization, however, will eventually reduce available inventories leading to higher prices, improved returns, and more intensive hardwood management. The NC State Hardwood Research Cooperative (HRC) has been investigating the productivity responses of very young (ages 1 to 10 years) even-aged hardwood stands to silvicultural treatments such as fertilization, herbicide release, individual-tree release, and various methods of stocking control. This paper discusses the potential impact of these treatments on hardwood productivity and estimates the extent to which expected productivity increases justify investment in various silvicultural treatments.

Early hardwood stand interventions

Recent research at the HRC has demonstrated substantial growth responses in very young natural stands to silvicultural treatments that reduce biological constraints on productivity (Newton et al. 2002, Romagosa and Robison 2002, Schuler and Robison 2002). In these studies in stands aged 1 to 10 years, activities such as stem density reduction, herbaceous competition control and fertilization have yielded growth up to 33-fold greater than in control plots. These types of responses, yielding fewer larger trees per unit area, suggest that natural stands can be hastened down the self-thinning curve, and growth concentrated faster on the stems likely to be present at harvest. Even if such treatments and responses represent only brief intervals of enhanced productivity, the stand will not revert, but cumulatively gain from such changes. Modeling growth response of 17% to 33%, as reported in the current study (see below), seem reasonable given these measured responses.

The scenarios described below are based on the rationale that while each natural regeneration system has merits (Kellison et al. 1981, Kelty 1988), clearcut and shelterwood methods (Kirkham 1988) are most commonly recommended for regenerating southern hardwoods (McGee and Hooper 1970, Sander 1980, Frederick 1983). These approaches have low cost (Dutrow 1980, Shropshire 1980), and natural even-age regeneration tends to result in a mix of commercial and non-commercial, shade-tolerant and intolerant species, that meet the multi-use management objectives common to many landowners (Boyce 1977). And in these systems, as compared to the advances in pine production, comparatively little has been done to advance productivity (Kellison 1977, Buckner 1980, Robison et al. 1998).

Studies in natural hardwoods have long demonstrated that thinning can have many positive benefits in production forestry, provided damage to the residual stand and soils are prevented (Gingrich 1971, Heitzman and Nyland 1991). Few studies have reported on stands less than 10
years old. Fertilization in natural stands has been infrequently studied, with reports indicating a variety of stand responses (Dunn et al. 1999, Graney and Rogerson 1985, Farmer et al. 1970). It is well established that enhancing site resources through fertilization, and reducing inter-tree competition (and herbaceous competition) through density control, and these factors in combination, can enhance productivity, often for many years following treatment (Johnson et al. 1997).

Management scenarios

Three management scenarios were developed to represent increasingly intensive approaches to the management of hardwood and mixed pine-hardwood forests. The traditional scenario envisions no post-harvest investment and a 60-year rotation. The advanced scenario assumes some silvicultural treatments that increase growth and effectively shorten the rotation to 50 years. And the advanced plus scenario assumes more intensive silvicultural treatments that result in even higher growth and a shorter, 40-year rotation.

Final harvest in all three scenarios produces 126 green tons/ac distributed between pulpwood, chip-and-saw, and sawtimber. Harvest in hardwood forests produced sawtimber (72 green tons/ac) and pulpwood (54). In mixed pine-hardwood forests, harvest is composed of hardwood sawtimber (58 green tons/ac), pine sawtimber (14), pine chip-and-saw (2), hardwood pulpwood (41) and pine pulpwood (11). In-woods chipping increased hardwood and pine pulpwood yields by approximately 50%, effectively increasing the total harvest yield to 152 green tons/ac. There are no intermediate harvests.

Productivity growth is modeled by making rotations shorter, while maintaining the same final harvest yields for all management scenarios. As shown on Figure 1, the same yield curve is used for all scenarios. It is shifted to the left for both advanced scenarios to simulate productivity growth. That way final harvest will occur sooner, indicating faster growth. The advanced scenario represents a 17% growth in productivity, and the advanced plus scenario represents a 33% growth in productivity.

Returns

Given that early stand interventions have the potential to generate considerable growth in productivity of hardwood stands that will last throughout the rotation, the next question is how many dollars can be invested in these silvicultural treatments given the expected productivity gains. In other words, we would like to know how much can be invested in various silvicultural treatments in a way that would generate rates of return higher than or equal to returns in untreated stands.

Internal rate of return (IRR) was chosen as the measure of returns associated with hardwood and mixed pine-hardwood management. IRR represents the rate at which present value of revenues equals present value of costs or the rate earned when money is invested into a particular project. The decision rule is to accept a project when the IRR is higher than the interest rate at which one can borrow money.
Hardwood sawtimber is assumed to generate $22/green ton (traditional), $28 (advanced), and $30 (advanced plus). The small price increases are due to improved species composition. Pine sawtimber generates $36/green ton and pine chip-and-saw $22. Hardwood pulpwood and pine pulpwood generate $5 and $8/green ton, respectively. Annual administration and tax expenses are $5/ac. Hunting leases generate on average $3/ac annually. A common investment period of 60 years is assumed for all three management scenarios. It follows that during the investment period, there would be 1.2 rotations in the advanced scenario and 1.5 rotations in the advanced plus scenario.

In hardwood forests, revenues per acre at the end of investment period range from about $1,850 (traditional) to $2,570 (advanced plus). Thanks to higher valued pine timber, revenues in mixed pine-hardwood forests were higher and ranged about $2,120 to nearly $2,730. In short, a move from the traditional to advanced scenario increases revenues from 15% to 20%. A transition from the traditional to advanced plus scenario increases revenues from 20% to 30%. In-woods chipping adds only about 6% to revenues due to the fact that pulpwood values are relatively low. The remainder of this paper presents results only for hardwood scenarios (no mixed pine-hardwood), without in-woods chipping.

Traditionally managed hardwood forests yield an IRR of 7.3%. This rate serves as our benchmark for evaluating opportunities for silvicultural treatments. In the advanced scenario, the IRR increased to 10.2% and the advanced plus to 13.7%. The difference between IRRs for traditionally managed hardwoods and the advanced plus scenario amounts to 6.4%.

We also wanted to estimate how much can be spent on single and multiple (two) treatments at ages 1 through 15. Investment was gradually increased for selected ages in advanced and advanced plus scenarios until IRR reached the benchmark of 7.3%, yielding the maximum investment possible without reducing returns below what is observed in unmanaged stands. An IRR greater than 7.3% indicates greater economic returns.

Results presented in Table 1 indicate that the maximum investment (resulting in an IRR of 7.3%) in single silvicultural treatment in the advanced scenario ranges from $45 at age 1 to $125 at age 15 on a per acre basis. More resources can be spent for investment in the advanced plus scenario, where the maximum values range from $130 (age 1) to $350 (age 15). For multiple treatments, the maximum investment per treatment ranges from $25 (two $25 investments equal $50) to $42 ($84 total) in the advanced scenario. In the advanced plus scenario these values range from $70 ($140 total) to $115 ($230 total). In-woods chipping adds from $2 to $10/ac for treatment at ages 1 through 15.

**Discussion and conclusion**

The results indicate that there are significant opportunities for desirable financial returns in the management of hardwood and mixed pine-hardwood forests, given the productivity increases assumed for the advanced and advanced plus scenarios. The maximum investment in single treatment in young stands ranges from $45 to $350/ac. For multiple treatments, between $25 and $115/ac can be spent per treatment for improving productivity, while still achieving returns equal to those from natural stands. These amounts would readily pay for treatments such as
fertilization, herbaceous release, and stocking control, which, based on the evidence from research trials, would make possible the assumed productivity increases.

The results indicate that there is a good potential for higher returns. In the advanced plus scenario a manager can spend up to $130/ac on treatments at age 1, and produce more and better timber in a shorter time period, while earning the same IRR. The manager may decide, for example, to spend only $50/ac on selected treatments. If these treatments succeed in achieving the assumed growth in productivity, then IRR would increase to nearly 10% (Figure 2).

Forecasts of the future hardwood timber supply situation in the South also indicate that economic conditions will be suitable for increasing hardwood productivity as hardwoods will become increasingly scarce and their prices continue to grow. The findings from the current Forest and Rangeland Resources Planning Act (RPA) Timber Assessment (Adams 2002) indicate that southern hardwood harvests will continue to increase. Higher harvests combined with relatively low growth will result in inventory declines after 2010. As a result of less favorable hardwood supply, prices for both sawtimber and pulpwood are expected to grow. Similar developments are forecasted by a more detailed analysis carried out with Subregional Timber Supply Model (SRTS) as part of the Southern Forest Resources Assessment (Prestemon and Abt in press). As a result of growing harvests, hardwood inventories are expected to decline after 2025, and limited timber availability will drive prices higher. These price increases will provide additional incentives for intensified hardwood management, including silvicultural interventions in very young stands.

Literature cited


Table 1. Maximum investment yielding constant IRR (7.3%).

<table>
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<tr>
<th>Age</th>
<th>Advanced ($/ac)</th>
<th>Advanced Plus ($/ac)</th>
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</table>

Figure 1. Hardwood timber yields.
Figure 2. IRR vs. investment expenditure in hardwood stands at age 1.