Effects of Management Variables on Net Present Value in Uneven-aged Loblolly Pine Stands
by
Michael J. Cafferata and W. David Klemperer

Abstract
Simulated uneven-aged silvicultural regimes in loblolly pine are optimized by choosing the residual basal area, maximum diameter, diameter distribution, and cutting cycle which maximize net present value (NPV) under a benchmark set of inputs. Using the growth and yield model Southpro and starting with a balanced uneven-aged stand, we analyze the effects of cutting cycle, residual basal area, and maximum diameter on NPV. For the variable ranges tested and benchmark inputs, we find that NPV is maximized at cutting cycles between 5 and 9 years. Optimum cutting cycle and sensitivity of NPV to different cutting cycles depends on the harvesting cost assumptions. For the ranges tested and the benchmark inputs, NPV is found to be relatively insensitive to residual basal area and sensitive to maximum diameter. NPV is maximized when maximum diameter is 12 inches, and higher maximum diameters significantly reduce NPV. The site specific biologic conditions necessary for uneven-aged silviculture must be considered when viewing simulation results.

INTRODUCTION
Several trends are kindling more interest in uneven-aged silviculture: some localities have passed ordinances against clearcutting; public and private forest managers are becoming more interested in protecting scenic values and ecosystems; many non-industrial private forest owners are interested in timber harvest income but don't wish to clearcut; in visually sensitive areas on all forest ownerships, the public is increasingly upset about clearcutting. Some forest products firms in the loblolly pine region are voluntarily leaving buffer strips of trees along highways, streams, and other environmentally sensitive areas. Such scenic management zones may be ideal candidates for uneven-aged silviculture.

Little work has been done to compare net benefits of even-aged versus uneven-aged silviculture in loblolly pine. In uneven-aged systems, partial harvests occur every \( n \) years, where \( n \) is the cutting cycle. Eventually a multi-aged stand develops with roughly \( n \) years between age classes, since most regeneration occurs after each partial cut. Because clearcutting never occurs, the public generally feels that uneven-aged silviculture is more attractive and environmentally more acceptable. But even-aged silviculture with clearcutting is more common in loblolly pine because it usually brings greater financial rewards.

While even-aged forestry dominates in the southern pine region, uneven-aged loblolly pine silviculture is possible and has been practiced on some properties for many decades. Among these are the Crossett Experimental Forest in Arkansas, the John W. Starr Memorial Forest in Mississippi (Farrar et al. 1989), and in Hope, Arkansas (Farrar et al. 1984). Baker (1985) estimated that about 2 million acres of private forestland in the South were under uneven-aged silviculture in the early 1980s. Many forest landowners are interested in financial comparisons between even-aged and uneven-aged loblolly pine silviculture. A current study at Virginia Tech seeks to make such comparisons, and this paper reports on preliminary results in the uneven-aged phase of the research.

Previous work
Hotvedt et al. (1989) addressed optimum management regimes for uneven-aged loblolly-shortleaf pine stands managed under the selection system. The growth-and-yield model (Murphy and Farrar 1983) used in this study did not accommodate Q factor or maximum diameter-sized trees, two important management variables of uneven-aged silviculture. The top 5 NPV-maximizing regimes had cutting cycles of 4 or 5 years, residual basal areas between 45 and 65 ft\(^2\)/acre and sawtimber basal area to merchantable basal area ratios (SRAT) of .55.

Hotvedt and Ward (1990) present a general dynamic programming model which optimizes decisions in uneven-aged loblolly pine silviculture. Hotvedt and Ward found that the steady state regime which maximizes NPV depended on the forest’s starting condition, but generally the silvicultural optimum residual basal area was 50 or 55 ft\(^2\), SRAT was .50 or .55, and cutting cycle was 5 years. Because of the limitations of available growth models, this

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study also does not address the effect of different Q factors or maximum diameter on NPV.

APPROACH
Uneven-aged loblolly pine stand growth was modeled with Southpro (Buongiorno and Schulte 1997) a site- and density-dependent, multi-species matrix model for predicting the development of loblolly pine forests in the Mid-South (Buongiorno et al 1997). This growth and yield model allows modeling of residual basal area, maximum diameter, Q factor, and time, all the management variables needed for uneven-aged silviculture. It also allows modeling of irregular diameter distributions and can calculate value based on price/diameter relationships. Simulations sought an equilibrium “balanced uneven-aged stand” where the

![Figure 1. Starting Inventory for All Simulations.](image)

ratio of numbers of trees in succeeding dbh classes (N) is a constant called Q, and Q = Nt/Nt+1 (where I usually indexes dbh classes by one or two inch increments). Here all Q factors will be based on one-inch diameter increments.

We restrict management alternatives to conditions which assure continuation of an uneven-aged stand: residual basal area between 40 and 80 ft²/acre and maximum diameters capable of supplying seed sufficient for natural regeneration.

Figure 1 shows the diameter distribution (Q = 1.2) of the starting inventory for all simulations. The basal area is 65 ft²/ac, with a maximum diameter of 12” breast high (dbh). Table 1 shows the benchmark inputs for initial simulations. Equation 1 shows the equation for calculating NPV.

Equation 1. Equation for Calculating NPV

\[
NPV = \sum_{t=0}^{200} R_t (1 + i)^{-t} - \sum_{t=0}^{200} C_t (1 + i)^{-t}
\]

Where: \( t = \) time, \( R_t = \) revenue occurring in year \( t \), \( I = \) interest rate, and \( C_t = \) costs occurring in year \( t \).

Table 1. Benchmark Inputs for Simulations

<table>
<thead>
<tr>
<th>Benchmark Inputs</th>
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<tbody>
<tr>
<td>Prices</td>
</tr>
<tr>
<td>$16/cord pulpwood</td>
</tr>
<tr>
<td>$150/mbf scribner chip-n-saw (10”- 12” dbh)</td>
</tr>
<tr>
<td>$225/mbf scribner sawtimber</td>
</tr>
<tr>
<td>Interest rate = 7 percent</td>
</tr>
<tr>
<td>Lobolly Pine Site 85 (base age 50)</td>
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</tbody>
</table>

RESULTS
Figure 2 shows the NPV of uneven-aged regimes, under the benchmark assumptions, for cutting cycles from 3 to 9 years. Residual basal area is 45 ft²/acre and maximum diameter is 14 inches for each of the cutting cycles tested. When harvesting costs vary little with harvesting intensity, NPV is relatively insensitive to the cutting cycles tested. NPV is maximized at cutting cycles between 5 and 9 years. When harvesting costs vary more highly by percent volume removed, such as under the high harvesting cost scenario, NPV is more sensitive to cutting cycle, and NPV is maximized at the longest cutting cycle tested.

Figure 3 shows the effect on NPV of different levels of residual basal area. Cutting cycle is held to 5

![Figure 2. Effect of Cutting Cycle on NPV](image)

years and maximum diameter is held to 14 inches. Harvesting costs do not vary greatly with percent volume removed (low harvesting cost difference from Figure 2). This shows, for the levels of the variables tested, that NPV is not highly sensitive to residual basal area, however higher residual basal areas yield slightly higher NPVs.

Figure 4 shows the effect of different maximum diameters on NPV. Cutting cycle is 5 years, residual basal area is 45 ft²/acre, and the low harvesting cost difference scenario is used. For the
levels that suppers natural regeneration. The combination of cutting cycle and residual basal area must be carefully considered.

**Literature Cited**


