CENTRAL HARDWOOD NOTES

Thinning Even-Aged, Upland Oak Stands

Thinning produces bigger and better trees faster. Thinning removes poor quality trees and concentrates growth on the best. Total wood production increases because trees that would otherwise die from competition are harvested. Rotation ages for sawtimber can be shortened as much as 20 years. Or, we can grow bigger, more valuable trees using the same rotation age as an unthinned stand.

Four basic questions arise in thinning: (1) How, (2) When, (3) How much, and (4) How often do we thin? The answers depend a lot on management objectives. For example, thinning strategies to produce wildlife habitat are different from strategies to maximize pulpwood or saw log production. Even after the objective has been established, the answers are still complex because the expected growth and yield varies by such factors as stand age, residual stand density, and site productivity (fig. 1 a, 1 b).

Figure I.-(a) An unthinned upland oak stand. (b) Extremely heavy thinning in an upland oak stand

In this Note we discuss the general concepts of tree and stand responses to thinning. We also present thinning recommendations to produce high-value sawtimber. We limit our discussion to immature stands 30 years and older.

Sapling and mature stands are discussed in other Notes. We also limit our discussion to those central hardwoods we know the most about: even-aged upland oak stands that are fully stocked before thinning. Upland oak stands are composed primarily of white, black, scarlet, chestnut, and some northern red oaks.

How **to Thin Your Upland Oak Stand**

First, find out what you actually have on the ground. Determine the basal area and number of trees per acre using standard inventory procedures. Use these values to determine relative stand stocking from the stocking chart for upland oaks (fig. 2). The A-line on the chart represents average maximum stocking.

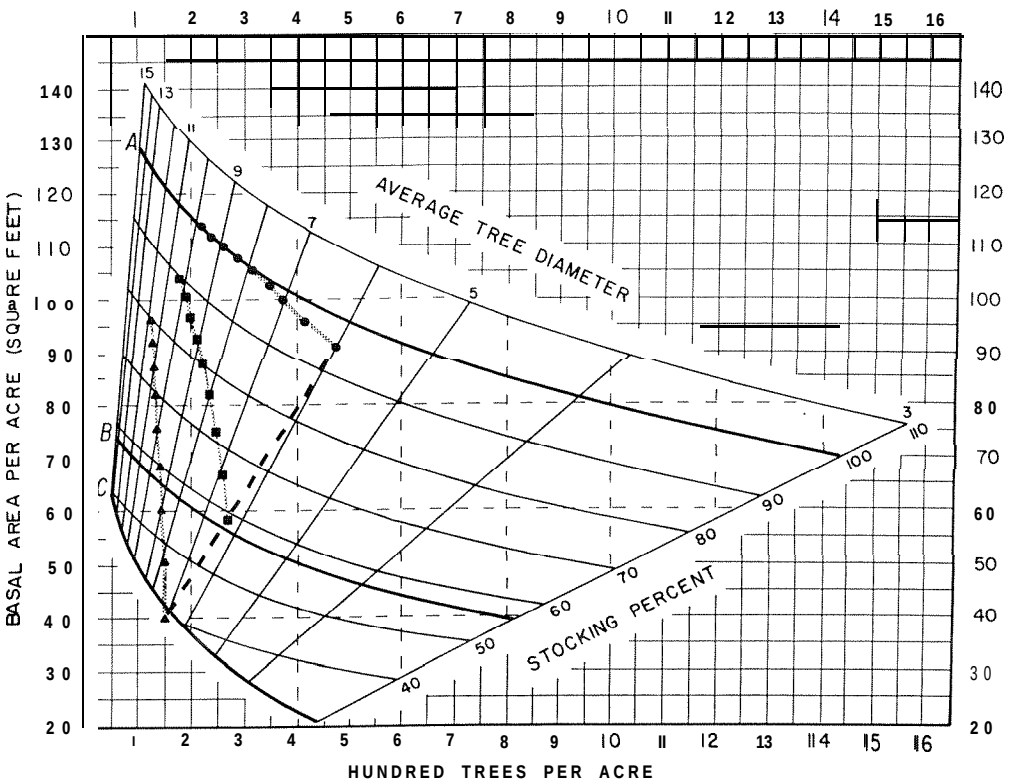

Figure 2.- Stocking chart for upland oak stands. Thinned and unthinned sample stands. Development of an unthinned stand (●) and thinnings to 60 percent (■) and 40 percent (▲) are shown for a 40-year projection. Each symbol represents a 5-year growth period.

Using a 40-year-old stand with a site index of 65 as an example, suppose a field inventory indicates that our stand has 92 square feet of basal area and 480 trees per acre. The chart reveals that it is about 96 percent stocked. A stand with such high stocking could benefit from thinning. A light thinning reduces the stocking to about 80 percent stocking, a moderate thinning to 60 percent, and a heavy thinning to 40 percent. We'll decide later on a thinning strategy for our stand, but let's look now at how to thin, regardless of residual stocking.

The method most frequently used to thin upland oaks is best called "free" thinning-the marker is free to remove trees from all crown classes. The objective is to leave the specified stocking distributed on the best trees as evenly spaced as possible. With due regard for wildlife objectives, larger cull and defective trees are cut first, then competing trees of poor form and quality, then intermediate and suppressed trees of lower quality and value. Finally, lower value species or even some desirable trees are removed from the main canopy if necessary to achieve uniform spacing and the target stocking level.

Free thinning is applied area-wide, as opposed to crop tree release thinnings. Nevertheless, we still concentrate on releasing the best trees. A light thinning to 80 percent residual stocking will not release many of the best trees. However, with a moderate thinning to 60 percent aim to release two or three sides of the crown on the best trees. A heavy thinning to 40 percent will release all four sides of the crown on most residual trees.

The First Thinning

The first thinning is the most important because: (1) it is usually made in younger stands that respond best, (2) it usually provides immediate financial returns from harvested products, and (3) it strongly influences the multiple use values of the stand for many years. The number of cords harvested from different age stands on an average site for upland oaks is shown in figure 3. The heavier the thinning, the more cords harvested. A 5-cord cut is a good rule of thumb for a minimum cut that will interest timber buyers. Figure 3 reveals that we would have to thin a 30-year-old stand on site index 65 below 40-percent stocking to get 5 cords per acre. But wait until age 40 and we can cut about 6 cords if we thin to 60 percent, and about 9 cords if we make a heavy thinning to 40 percent.

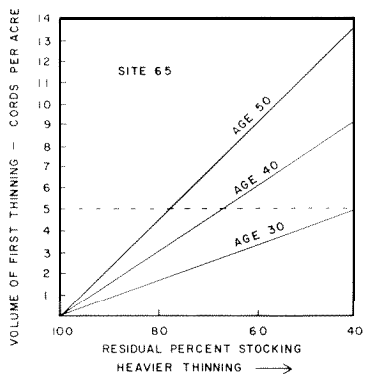

Figure 3.-Cords of wood harvested by thinning at various stand ages for site index 65.

Stand Response to Thinning

So a 40-year-old stand on site index 65 will produce at least 5-cords if we thin to 60 percent stocking. Let's also look at a heavy thinning to 40 percent stocking and then grow both stands to a rotation age of 80 years with a computer growth and yield program called OAKSIM. Development of both thinned stands, and an unthinned stand, is plotted on the stocking chart in figure 2.

Although we cut some bigger trees, a lot of small trees are also removed in thinning. Thus, the average diameter of the residual stand is increased: the heavier the thinning, the larger the average diameter. The unthinned stand tracks along the 100-percent-stocked A-line over the 40-year projection. The two thinned stands approach average maximum density as they move towards the A-line over time. There is little or no mortality in upland oak stands when stocking is below 60 percent.

Cubic foot volume growth and yield values are shown in figure 4. Cubic volume is to a It-inch inside top diameter for trees with at least a 4 foot bolt. For any 5-year growth period, gross growth (net growth + mortality) is constant over a wide range of densities from 100 percent down to 40 or 50 percent. Gross growth expresses the growing capacity of a given site. Net growth increases with thinning down to 40 to 50 percent stocking because mortality is reduced. Volume normally lost as mortality is salvaged by thinning. The increase in net growth explains why the yields of our two thinned stands approaches the unthinned stand over time. However, as stocking increases, the net growth rates of the thinned stands begin to decline (fig. 4). A second thinning at ages 60 to 65 may be appropriate. Thinning below 40 percent stocking causes both gross and net growth to decline because there are simply too few trees to utilize the space available.

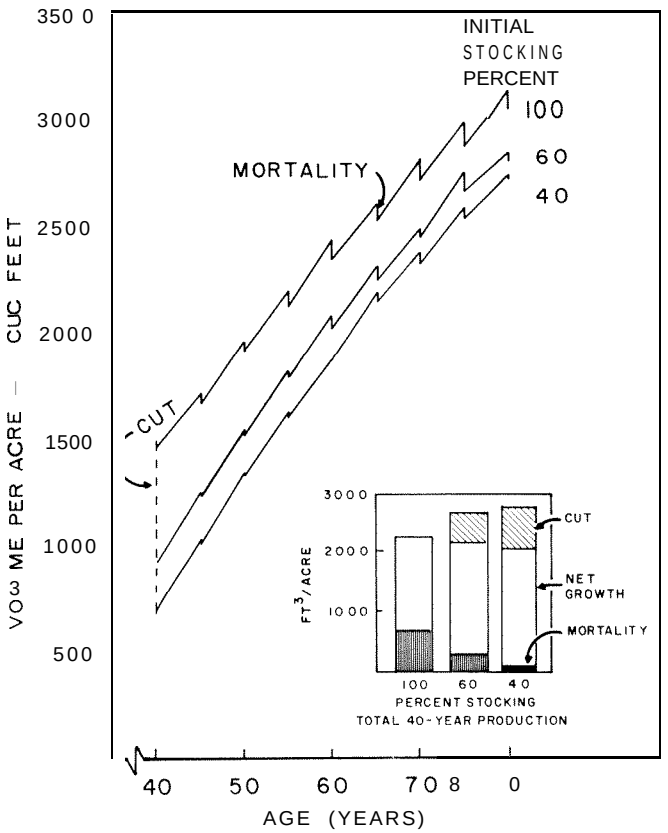

Figure 4.-Cubic foot volume growth and yield of sample stands on site index 65 unthinned and thinned to 60 percent and 40 percent stocking at age 40.

Total yields (final volume + cut volume removed in thinning) at the end of the 80-year rotation were: 3008 cubic feet per acre for the unthinned stand, 2,797 + 472 = 3,269 for the 60 percent thinning, and 2,705 + 689 = 3,394 for the 40 percent thinning. So we can boost total wood production about 9 to 13 percent with one early thinning. Additional thinnings would increase these percentages.

Tree Response to Thinning

Diameter growth of individual trees increases after thinning: the heavier the thinning, the more the increase. Diameter growth continues to increase even down to 20 percent stocking, but at this level there would be a big loss in stand volume growth. A light thinning (80 percent stocking) increases diameter growth of the larger residual trees about 10 to 20 percent, a medium thinning (60 percent stocking) about 40 to 50 percent, and a heavy thinning (40 percent stocking) about 80 to 100 percent.

In the two thinned stands, increased diameter growth produced more sawtimber trees at age 80. The unthinned stand has only 34 trees greater than 11.6 inches at age 80, compared to 41 for the 60 percent thinning, and 56 for the 40 percent thinning. Average stand diameters of all trees at age 80 was 9.7 inches for the unthinned stand, 10.1 inches for the 60 percent stand, and 11.5 inches for the stand thinned to 40 percent. The unthinned stand has only two trees that could qualify as Grade 1 (greater than 16 inches d.b.h.), the 60 percent thinning has 3, and the 40 percent thinning has 8. Additional thinnings would increase the number, size, and value of these sawtimber trees even more.

So far, the logical residual stocking level appears to be 40 percent. Gross growth per acre is not reduced, total production is maximized, and individual trees grow a lot faster. However, there are other factors to consider. While thinning does not significantly affect oak stem form, tree quality is another story. Some species, especially white oak, develop epicormic branches when stocking is reduced below 60 percent. In the absence of shading, these branches persist and become serious defects. To be on the safe side, 60 percent is often the recommended residual stocking level for species prone to epicormic branching. If the stand is composed primarily of the red oak group, we might cautiously thin down to 40 percent. However, as a compromise between growth and quality considerations, we recommend 50 percent as the lowest residual density.

Thinning Guidelines for Upland Oak Stands

The two thinnings we discussed in this Note were only for one age and one site index. The development of thinning guidelines is complex because we must consider various ages, sites, and rotation ages, along with when, how much, and how often to thin. In summary:

When to Thin

Commercial thinning (at least 5 cords per acre) may begin as early as 30 years in upland oak stands on site index 80 or better. On site 70 we have to delay the first cut until age 35, and on site 60 we should be able to start by age 40.

How Much to Thin

Regardless of the site, the first thinning should be as heavy as possible. Young stands respond most to thinning and the crowns close very quickly. If the stand is predominantly black oak and/or red oak, thin to the 50 percent stocking level. If the stand is predominantly white oak that could produce epicormic branches, only thin to 60 percent. If the stand is a mixture of black, red, and white oaks, thin to 50 percent. Trees that develop too many epicormic branches can be removed in later thinnings.

Subsequent thinnings should not reduce residual stocking below 60 percent. This stocking level will allow us to remove trees that developed epicormic branches after the first thinning, maintain vigorous growing conditions, upgrade quality, and permit the stand to approach average maximum density (A-line stocking) before harvest. You should aim for a well stocked stand with at least 50 high quality trees per acre for the final harvest cut.

How Often to Thin

Frequency of thinning depends on the intensity of the first and subsequent cuts, site index, and rotation age. Rotation age varies with site index if our goal is to produce high quality saw logs: 80 years for site index 80, 100 years for site 70, and 120 years for site 60. Shorter rotations simply do not produce enough sawtimber-size trees. Given these rotation ages and the initial thinnings discussed above, subsequent thinnings to 60 percent stocking can be made at age 50 for site 80, age 60 for site 70, and age 70 for site 60. These thinnings would produce a commercial 5-cord cut, maintain vigorous growing conditions, and allow the stand to close just before harvest. If the rotation age changes, then the frequency of thinning could also change. For example, if the rotation age for site 80 were lengthened to 100 years to produce more veneer logs, we could easily make a third thinning.

Thinning for Specific Applications

Detailed thinning prescriptions for specific upland oak stands can be developed with computer programs like OAKSIM. We have not discussed thinning guidelines for mixed species, uneven-aged, central hardwood stands. You can use such

programs as TWIGS to develop thinning guidelines for these kinds of stands. For information on TWIGS *see* Note *5.10 Growth and Yield Models for Central Hardwoods.*

References

Dale, M.E.; Hilt, D.E. 1986. Thinning pole and sawtimber mixed oak stands. In: Smith, H.C.; Rye, M.C., eds. Proceedings, Guidelines for managing immature Appalachian hardwood stands; 1986 May 28-30; Morgantown, WV. Morgan town, WV: West Virginia University College of Agriculture and Forestry: 99-117.

Gingrich, Samuel F. 1967. Measuring and evaluating stocking and stand density in upland hardwood forests in the central states. Forest Science. 13: 38-52.

Hilt, Donald E. 1985a. OAKSIM: an individual-tree growth and yield simulator for managed, even-aged, upland oak stands. Res. Pap. NE-562. Broomall, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 21 p.

Hilt, Donald E. 1985b. User's guide to OAKSIM: an individual-tree growth and yield simulator for managed, even-aged, upland oak stand. Gen. Tech. Rep. NE-1 04. Broomall, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 22 p.

Hilt, Donald E. 1987. Using OAKISM: an individual-tree growth and yield simulator for managed, even-aged, upland oak stands. In: Proceedings, 15th annual hardwood symposium; 1987 May 1 O-l 2; Memphis, TN. Memphis, TN: Hardwood Research Council: 67-86.

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