CENTRAL HARDWOOD NOTES

Estimating Oak Growth and Yield

Yields from upland oak stands vary widely from stand to stand due to differences in age, site quality, species composition, and stand structure. Cutting history and other past disturbances such as grazing or fire also affect yields.

The old normal yield tables for upland oaks based on unmanaged stands are no longer suitable for modern timber management. Today's managers need information on how yields vary in relation to relative stand density and species composition. They also need to know how the yields may be altered by various thinning strategies or other timber management practices. This information is available through stand models.

Managed Stand Yield Models

Growth and yield predictions in the upland oak timber type have been available for managed stands for several years. Most stand models use equations that relate stand age, site, relative stand density, or other attributes to stand growth and yield expressed in basal area, cords, or board feet. Yields from these models are based on long-term measurements of permanent growth plots. Predictions are derived from data representing a wide range of site, age, and density conditions from both thinned and unthinned stands. When these equations are used in computer programs to simulate stand growth they provide an extremely useful tool (see Note 5.10 Growth and Yield *Models for* Central *Hardwoods).* Managers can use these computer models to answer questions such as:

How do stands respond to various thinning treatments?
What is the best age to thin?
How much volume should I cut or leave?
How long should I wait for a second or subsequent cutting?
How long should the rotation age be?
How do I determine the relative productivity between sites or age classes?

Individual Tree Growth and Yield Models

Individual tree growth and yield models are newer and provide more detailed information than stand models. Models like TWIGS or OAKSIM for the upland oaks (see Note 5.10 Growth *and Yield Models for* Central *Hardwoods)* keep track of the growth and mortality of individual trees in a stand. Using tree size and species, managers can more accurately assign tree grade or quality to determine tree and stand market values. Individual tree models are used to answer the same questions as before on the timing, intensity, and frequency of thinning, but they can provide greater reliability than stand models. The growth and yield predictions presented here and the management recommendations given in Note 6.06 *Thinning Even-aged Upland* Oak *Stands,* are based in part on the individual tree growth model-OAKSIM.

Upland Oak Yields

Figure 1 illustrates typical yields for even-aged unmanaged upland oak stands from 30 to 90 years old on fair, average, and excellent sites (site index 50, 65, and 80). We assume that unthinned stands are very well stocked; about 80 percent of the average maximum density presented in normal yield tables. Yields, especially the board foot volume, are substantially more on the better sites. Usually there are more trees on the poor sites at a given age but they are smaller, so it takes longer to reach merchantable size. On excellent sites some trees start reaching merchantable sawtimber size (12 inches d.b.h.) as early as 35 years while on poorer sites it may take 50 or 60 years. The graphs in figure 1 indicate that both site and age are important factors that influence the yield from typical unthinned upland oak stands.

Species composition has a large influence on stand yields. The yields in figure 1 are based on stands with more of the slower growing white oak than the faster growing black, scarlet, or northern red oak. For a given age and site, stands that are predominantly black oak or red oak would have considerably higher yields than shown in figure 1.

Relative stand density is another important factor that influences yield. If your stand does not have as much basal area for a given age and site shown in figure 1 a, then your yields should be reduced proportionately. For example, on an average site, at age 60 we would expect about 85 square feet of basal area and a yield of almost 2,500 cubic feet (fig. la, lc). If your stand has 50 square feet of basal area (60 percent of expected), then your total yield (in cubic feet) would be about 60 percent of 2,500 cubic feet or only about 1,500 cubic feet.

Growth of Managed (Thinned) Upland Oak Stands

The forest manager can manipulate relative stand density by various thinning regimes and strongly influence growth and yield. Because net growth of the residual stand increases after thinning, the total yield from thinned stands usually exceeds the yield of unmanaged stands. Commercial thinnings usually can be made as early as age 30 and continued to age 90. Such practices will substantially increase net growth of the residual stand.

The periodic annual growth estimates in table 1 reveal some important trends regarding upland oaks. Young stands produce more annual cubic volume growth than older stands. For a given age, thinning to 40 percent stocking produces more net growth than thinning to 60 percent; and 60 percent residual density produces more growth than unthinned stands.

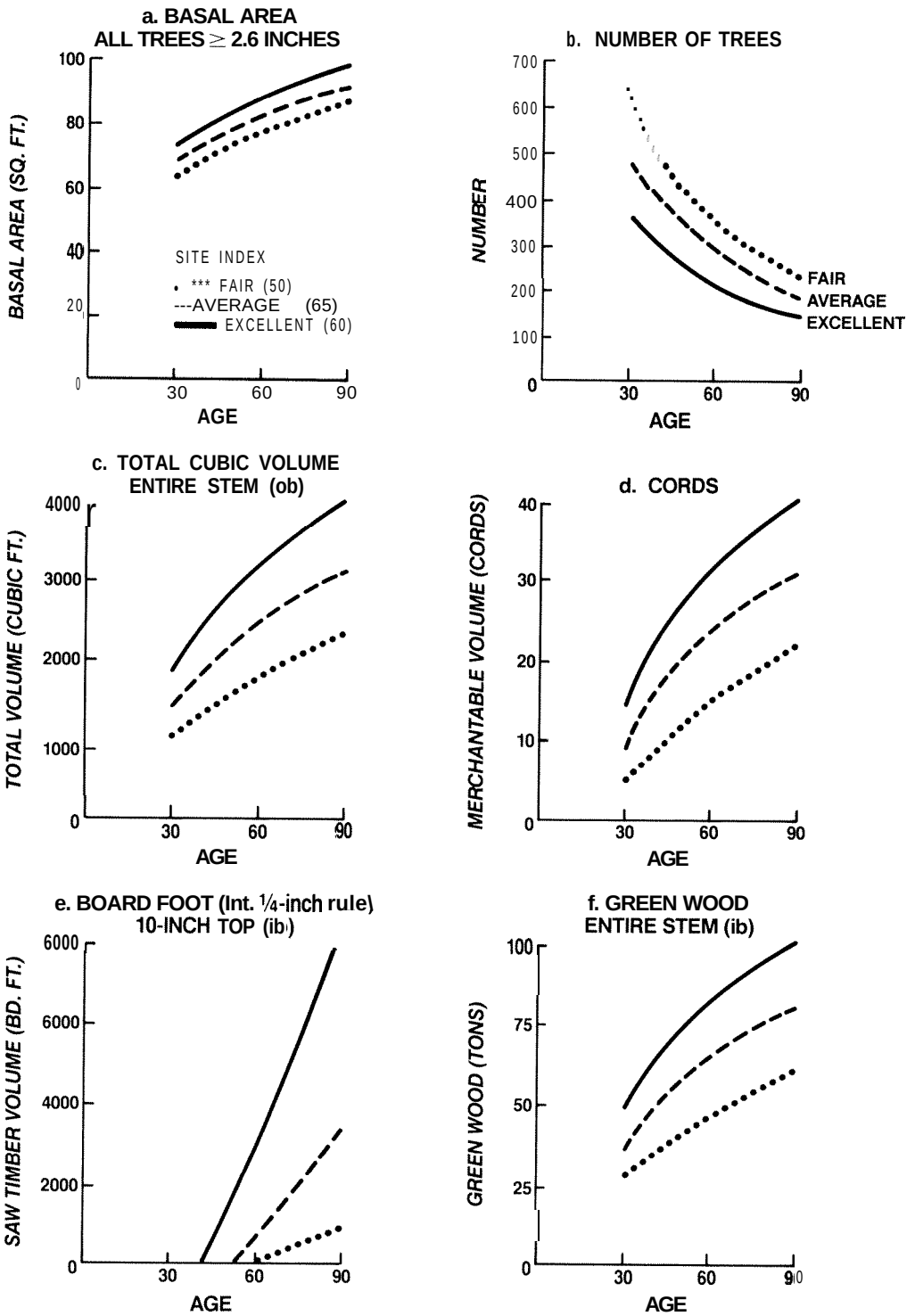

Figure 1 .-Yields of typically stocked unmanaged upland oak stands.

Table 1 .--Comparison of periodic annualgrowth for thinned versus unthinned oak stands on average sites

Stand age (Years)	Stand attribute	Unthinned		Thinned			
				60 percent stocked		40 percent stocked	
		Net	Gross	Net	Gross	Net	Gross
30	Basal area, square feet	1.8	2.7	2.3	2.6	2.5	2.5
	Total cubic feet	66	81	72	79	73	74
	Merchantable cubic feet	63	66	62	65	65	65
	Green wood. tons	1.7	2.2	1.9	2.0	1.9	2.0
60	Basal area, square feet	1.0	1.7	1.5	1.7	1.6	1.6
	Total cubic feet	51	67	60	66	64	65
	Merchantable cubic feet	49	58	53	56	54	54
	Green wood, tons	1.4	1.8	1.6	1.7	1.7	1.7
	Board foot volume	95	95	105	105	135	135
90	Basal area, square feet	0.8	1.4	1.1	1.4	1.3	1.3
	Total cubic feet	42	58	51	58	53	53
	Merchantable cubic feet	40	49	45	50	45	45
	Green wood, tons	1.1	1.5	1.3	1.5	1.4	1.4
	Board foot volume	183	188	219	219	250	250

Natural Mortality in Oak Stands

Mortality, the difference between net and gross growth, increases with residual stocking (table 1). When stands are thinned to 60 percent or less stocking, mortality is slight. In unthinned stands mortality can approach 40 percent of the basal area growth potential. Most mortality in young stands is confined to small trees that usually are too small to be merchantable. Mortality of merchantable size trees is not significant until stands become older. Even at age 90 sawtimber mortality is slight. In unthinned stands only a few trees reach sawtimber size by age 90, whereas in stands regularly thinned to 40 or 60 percent stocking many trees are large enough for sawtimber. Growth estimates in table 1 apply to typical oak stands on average sites-site index 65. Growth estimates vary with site by approximately the same percentage differences given for the yield estimates in figure 1.

Individual Tree Growth

Total stand growth is only one factor managers should consider when evaluating management options. Growth of individual trees is also important, especially the 50 to 80 largest trees per acre that constitute the final harvest.

The largest 80 crop trees per acre respond to the same factors as total stand growth (fig. 2). In addition to the stocking and age effects shown in figure 2, diameter growth also varies with site quality and species. In upland oak stands the black oak group (northern red, black, and scarlet oak) grow faster than the white oak group (white, chestnut, swamp white, post, burr, and chinkapin). Associated species such as hickory, beech, blackgum, and sugar maple grow slower than yellow-poplar, ash, aspen, black cherry, black walnut, and elm. Diameter growth is less affected than stand volume growth due to site differences; even so, a 1 O-point change in site index may alter diameter growth 10 to 15 percent.

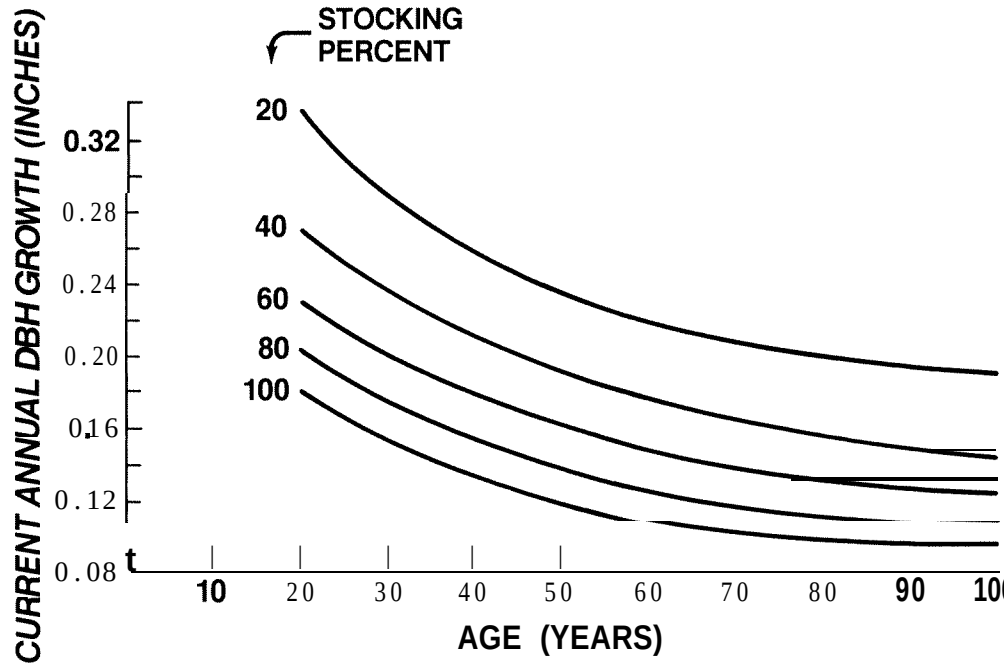

Figure 2.-Current annual diameter growth of largest 80 trees per acre by age and stocking percent.

As shown in figure 2, individual tree diameter growth increases as relative stand stocking decreases. However, with stocking below 40 percent there are too few trees to occupy the site fully and total stand growth is reduced. A more serious problem with low stocking is the potential for quality loss. Many tree species, especially white oak, develop epicormic branches when stocking is reduced below about 50 percent. You should select crop trees with vigorous, well-developed crowns, having a dominant or strong codominant crown position. Most importantly, crop trees should be free from small epicormic branches or bud clusters. Such trees can be readily identified for removal by the careful tree marker.

Within acceptable stocking levels diameter growth on the largest 80 trees per acre can be increased substantially-at least 75 to 80 percent over unthinned young stands. Growth on the largest 80 trees per acre may be less than 20 percent of the total stand growth at age 30, but in well-managed older stands all the potential growth should be concentrated on as few as 50 to 80 trees per acre.

By thinning throughout the rotation, you can concentrate growth potential on these few crop trees and produce bigger and more valuable trees at the final harvest.

References

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Also, see References in Note 6.06 *Thinning Even-aged Upland Oak Stands.*

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