



CENTRAL HARDWOOD NOTES

Estimating Growth And Yield Of Mixed Stands

A mixed stand is defined as one in which no single species comprises more than 80 percent of the stocking. The growth estimation methods described below can be used not only in mixed stands but in almost any stand, regardless of species composition, age structure, or size structure. The methods described are necessary to accommodate the complex species mixtures and irregular size distributions characteristic of many central hardwood stands. These same methods can also be used in pure or even-aged stands, although they will not always be best for those stands.

Two methods to estimate growth of mixed stands are (1) stand table projection, and (2) individual-tree-based simulation models. To use either method you need to sample the number of trees per acre by species and size. Information on tree quality may also be desirable for better value estimates. You can collect these kinds of information using any of the common forest sampling schemes designed to tally tree characteristics. For stand table projection this information is summarized into a stand table by species, and diameter class. For individual-tree-based simulation systems the sample information is entered as a list of the sampled trees, including species, diameter, quality class, and number of trees per acre represented by each sample tree.

Stand Table Projection

One of the oldest and simplest ways to project the growth and yield of mixed-species stands is by stand table projection. This technique is described in detail in most forest mensuration texts. Stand table projection begins and ends with a stand table showing the number of trees by species and diameter class. Future stand tables are predicted by estimating the number of trees of each species moving to different diameter classes for each projection period (usually a decade). The projected stand table can be used to estimate growth and future volumes by species and size classes.

To use traditional stand table projection you must (1) estimate periodic diameter growth by species and diameter class, (2) estimate periodic survival rates by species, (3) estimate periodic ingrowth, and (4) have a local volume table. These estimates are used to “move” the initial stand table to a future condition, species by species and diameter class by diameter class. Estimates for (1), (2), and (3) can be obtained from continuous forest inventory (CFI) plots or from increment cores taken at the time the initial stand table is developed. In general, these projections are excellent short term estimates because the best indicator of how trees will grow in the near future is how they grew in the recent past. Stand table projection generally works well for understocked or uneven-aged stands. However, stand table projection is not appropriate for all situations. In young, dense

stands with high ingrowth or in dense or overmature stands with high mortality, stand table projection is usually not appropriate because ingrowth and mortality estimates are imprecise under those conditions. Also, stand table projection does not account for changes in tree height or form, and these can have a significant effect on volume changes. This is particularly true in long term projections for well stocked, even-aged stands. It is not advisable to make stand table projections of longer than 20 years.

The biggest drawback to stand table projection is that for most applications foresters and landowners are unwilling or unable to take the large number of increment cores or to maintain CFI plots needed to estimate local growth, survival, and ingrowth. A prudent compromise is to use as many site-specific growth and survival observations as possible and, if necessary, supplement them with regional estimates from sources such as those listed under References.

Although you can project stand table data manually, personal computer programs like YIELD-MS provide easy-to-use stand table projection algorithms. They also provide excellent ways to enter and edit data and to prepare summaries of projected stand conditions. YIELD-MS can provide much more than traditional stand table projection. YIELD-MS includes options for economic evaluation of management alternatives, and includes default values for diameter growth and survival rates for many species in the central hardwood region. These rates can be used in lieu of local estimates or, preferably, used to supplement locally collected growth and survival information. With YIELD-MS it is particularly easy to select one of several different sets of regional growth and mortality rates, to incorporate locally observed rates, or to combine the two sources of information. One option in YIELD-MS is to generate growth and survival rate estimates from the mathematical models in the OAKSIM simulator (see Note 5.10 *Growth and Yield Models for Central Hardwoods*).

Individual-Tree Models

Individual-tree models are an extension of stand table projection with two important distinctions. First, individual-tree models require no prior aggregation of the individual tree inventory data describing the stand conditions. The projection begins and ends with a list of the individual trees sampled during a stand inventory. Growth and survival of each tree is projected, and the projected conditions for individual trees can be summarized and reported by combinations of species and/or size classes. The second important distinction is that individual tree projection systems include models that estimate diameter growth and survival rates for most important species, taking into account tree size and competition from surrounding trees. So you don't need increment cores or CFI plots before you can apply the models. However, information on local growth and survival rates can be quite valuable to assess model accuracy.

For the central hardwood region, the Central States variant of TWIGS is currently the most readily available individual-tree-based simulation system for mixed stands. TWIGS operates on common personal computers, it is easy to use, and it includes options for economic analysis of simulated management alternatives. TWIGS includes individual-tree growth and yield models for the species groups listed below. The models are applicable in Indiana, Illinois, and Missouri. A Lake States variant of TWIGS includes mathematical models for species and conditions in Minnesota, Wisconsin, and Michigan.

Species Groups for Central States TWIGS

White oak	Hickory	Black tupelo
Northern red oak	Ash	Other upland oaks
Scarlet oak	Black walnut	Other upland hdwds.
Black oak	Elm	Other lowland oaks
Blackjack oak	Sugar maple	Other lowland hdwds
Post oak	Silver maple	Noncommercial spp.
Chinkapin oak	Yellow-poplar	Eastern redcedar

TWIGS is generally applicable to pure or mixed forest types of any age or size distribution, provided the majority of the stand is in trees 1 inch d.b.h. or larger. Projections of longer than 30 years are not advisable. The models are based on tree growth and survival data from Indiana, Illinois, and Missouri, and predict regional averages. Actual growth for a particular stand may be higher or lower than the prediction. Data for local growth and survival rates should be compared to model predictions in order to evaluate model accuracy. Also, good data on local rates of diameter growth or survival can be used to adjust the models. The TWIGS models do not currently predict ingrowth, but user-supplied ingrowth estimates can be included in TWIGS projections.

One of the best uses for TWIGS is to compare management alternatives for specific stands. (Small, consistent overpredictions or underpredictions of growth do not generally affect the relative ranking of management alternatives.) Other uses include updating past forest inventories or projecting inventories into the future.

Example

The following example illustrates how you can apply either stand table projection or an individual-tree projection system to stand data in southern Indiana. The uneven-aged stand includes 6 species and has a site index of 85 for yellow poplar. For the 30 years from 1987 to 2017, the volume was predicted to increase from 950 to 5,170 board feet per acre while the number of trees decreased from 550 to 290 per acre (fig. 1). The estimated change for individual species can be followed in addition to total stand change. The species dynamics are illustrated in figure 2 which shows the distribution of basal area by species and 5-inch diameter classes for 1987 and 2017. In this example it is evident that basal area for maple,

American beech, and yellow-poplar increase at a faster rate than the other species, and elm basal area actually decreases. Additional simulation runs could be made for this stand to compare the predicted outcomes of different cutting alternatives, including comparison of the financial return of each of those alternatives.

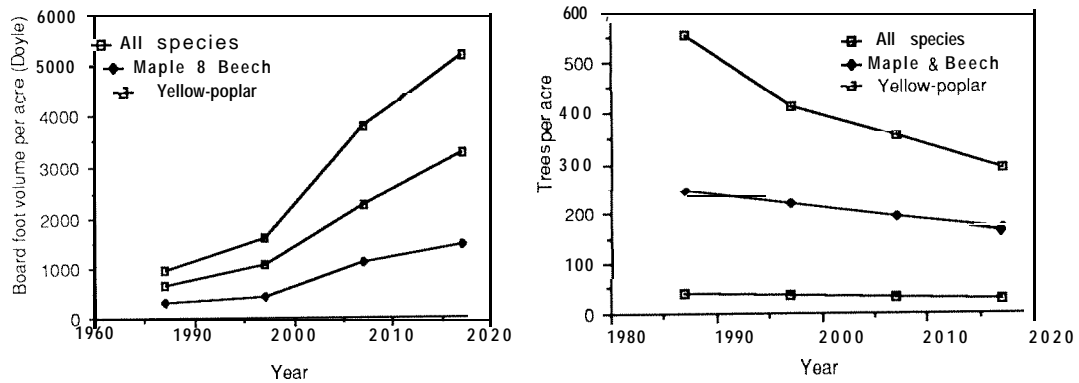


Figure 1.—Change in volume and trees per acre between 1987 and 2017 for a mixed stand with six species. Changes for maple, beech, and yellow-poplar are shown individually.

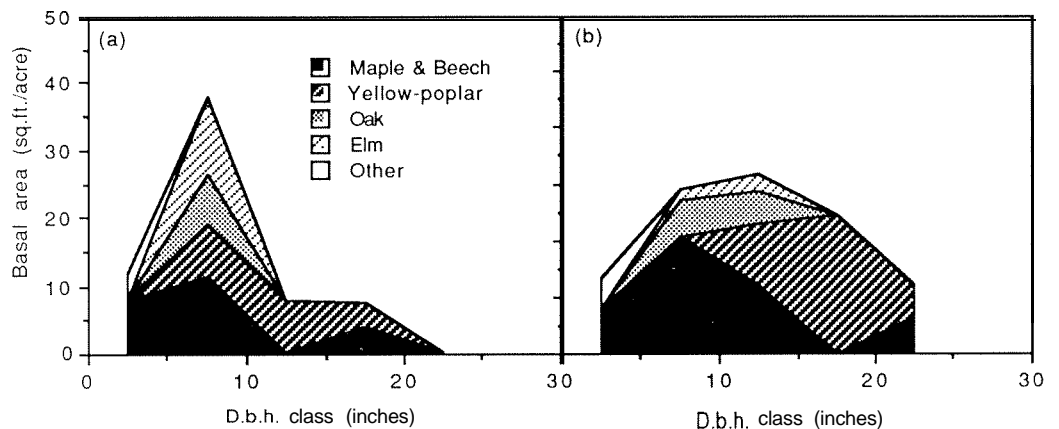


Figure 2.—Comparison of basal area by species and size class for a stand in 1987 (a) and as it is predicted for the year 2017 (b).

References

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- Miner, C.L.; Walters, N.R.; Belli, M.L. 1989. A guide to the TWIGS program for the North Central United States. Gen. Tech. Rep. NC-1 25. St. Paul, MN: U.S. Department of Agriculture, Forest Service, North Central Forest Experiment Station. 105 p.
- Shifley, S.R.; Smith, W.B. 1982. Diameter growth, survival, and volume estimates for Missouri trees. Res. Note NC-292. St. Paul, MN: U.S. Department of Agriculture, Forest Service, North Central Forest Experiment Station. 10 p.
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For more

information about: Contact

Minimum system configuration

YIELD-MS

Todd Hepp
Tennessee Valley Authority
Forestry Building
Norris, TN 37828
(615) 494-9800

PC with MS/DOS 2.0 or higher
320K memory
Two 5.25 inch disk drives
Hard disk, math coprocessor,
printer, and graphics monitor
recommended

TWIGS

North Central Forest Exp.Stn.
1992 Folwell Avenue
St. Paul, MN 55108
(612) 649-5173 or FTS
777-5 173

PC with MS/DOS 2.1 or higher
384K memory
One 5.25 inch disk drive
Second disk drive, printer
and graphics monitor
recommended

Stephen R. Shifley
North Central Forest Experiment Station
USDA Forest Service
St. Paul, Minnesota

Burnell C. Fischer
Department of Forestry and Natural Resources
Purdue University
W. Lafayette, Indiana