CENTRAL HARDWOOD NOTES

Introduction To Forest Growth And Yield

Forests are dynamic communities that are constantly changing. To the casual observer, only the most obvious change, such as the death of a tree, may be discernible. However, other changes are continually occurring. Trees grow in both height and diameter. This is termed survivor growth Ingrowth occurs when a tree's diameter grows larger than an arbitrarily specified lower size limit. Collectively, mortality survivor growth and ingrowth are designated as the components of forest growth. They are usually expressed on an annual basis and in units of merchantable wood volume.

A term very closely related to forest growth is forest yield. It is the sum of annual changes in the growth components. Thus, yield is the net volume of wood present in the forest at any given age while growth is the change in wood volume in a given year.

When you consider the concepts of forest growth and yield, some important questions are:

1. Why are growth and yield important to both the forester and the landowner?
2. How do you estimate growth and yield?
3. What factors affect forest growth?
4. Can growth be modified?

Importance of Growth and Yield

To manage a business, an organization, our personal finances or even a forest, we need to measure our ability to achieve a specific goal. For example, in managing our personal finances we may want to accumulate a certain amount of capital at the end of a given period. The annual interest or return corresponds to how fast our investment increases in value. We may express this increase in actual dollars or as a percentage increase which will let us compare alternative investment opportunities. The same concept may be used in managing a forest. The annual growth corresponds to interest income and may be expressed as either the absolute or percentage increase in wood volume. In both illustrations, the yield or net amount present at the end of a given period is represented by the summation of the annual increases added to the initial amount with which we began. The only difference is the units to express the principal-dollars versus wood volume.

From the foregoing analogy, it is easy to understand why growth is called "the lifeblood of the forest." The dynamic processes of mortality, survivor growth, and ingrowth are the record of changes in the forest resource. Both the forester and the landowner can use estimates of these changes or "growth" to evaluate their

management activities and forestry investments. In planning forestry operations, estimates of future wood volume that will accumulate frdm alternative management practices are absolutely essential. Growth and yield data are the sole source of these predicted values.

A service forester explaining management alternatives to a landowner.

Estimation of Growth and Yield

Growth estimates may be obtained for individual trees or for the entire forest. If your objective is to evaluate the quantity of various products that can be obtained from a mixture of species that comprise your forest, then an individual tree approach is ideal. On the other hand, if your interest is just to evaluate the total increase in volume, then a stand level approach would be appropriate.

An individual tree approach can be as simple as recording successive annual bole circumference measurements. This is exactly the process used by foresters. All trees are periodically remeasured on permanent plots established throughout a forest. These data are used to develop equations that describe the growth of individual trees in relation to their surroundings. An example of this approach is TWIGS, a computer program to "grow" a list of individual trees. The use of TWIGS is described in Note 5.10 Growth *and Yield Models for Central Hardwoods.*

The growth of individual trees can be collectively summarized to obtain yield tables. A yield table contains the net volume per acre for a given species, age, and site index. Some yield tables may also use stand density as an additional variable. In the past, the majority of yield information was provided in tabular form; however, today it is often expressed as a mathematical equation. This is convenient for calculating growth estimates and for including yield estimates in computer programs. A stocking chart is included in Note 5.02 Stocking Chart for *Upland Central Hardwoods.*

Factors Affecting Growth

There are many complex and interrelated factors that influence the quantity, quality, and distribution of growth in a forest stand. Some of the more important factors are:

site quality	environmental conditions
stand age	species composition
stand stocking	stand density

Site quality refers to the capacity of the soil at a given location to produce a crop of trees. Characteristics such as soil depth, nutrient and moisture content, and soil structure significantly relate to tree growth. All trees do not respond the same on a given site. Each species has its own physiological requirements and responds uniquely to a given site. Environmental and climatological factors strongly relate and interact with the soil conditions. The majority of site and environmental factors are not easily changed. A fundamental management practice is to prudently match species' requirements with site characteristics.

Individual trees as well as whole stands have characteristic growth patterns that depend on age. For very young trees, growth is slow. This is followed by a period of very rapid increase that gradually tapers off and ultimately declines in old trees. Stand growth follows a similar pattern. While the growth pattern may be similar for all species, the quantity of growth will vary by species and site. Age and site quality are the primary variables used to estimate growth and yield.

Stocking and *density* are terms to describe the extent to which the productive capacity of an area is being realized. A stand may be characterized as overstocked, understocked, or fully stocked. These terms imply a subjective indication of the number of trees that produces optimum growth. Stand density, a way of quantifying stem crowding, may be expressed as square feet of basal area, degree of crown closure, volume of wood or number of trees. Very dense stands grow at reduced rates while low density stands do not achieve the full productive potential of the site. Acceptable growth may be obtainable somewhere within a

wide range of stocking and density levels but it is often difficult to recognize the proper levels. Stocking charts that relate basal area, average diameter, and number of trees to stocking percentages are valuable aids to determine if a stand is attaining its potential. Upland oak stocking charts are included in Note 6.06 *Thinning Even-Aged, Upland Oak Stands..*

Modifying Growth

For a given site, species mixture, and stand condition, there is a finite amount of growth that can occur. One management option may be to leave the stand grow and develop according to natural competition. An alternative may be to consider modifying the stand through such cultural operations as thinning or timber stand improvement. Such treatments should consider species composition, spacing between trees, tree size, tree quality, and the space available for tree crown development. The decision to remove individual trees should be made to provide residual trees with optimum growing space. So, the site's full growth potential is concentrated on fewer, faster growing, better quality trees, which lowers competition among remaining stems and reduces the mortality component of growth. Growth and yield equations that reflect such cultural treatments enable the forester and landowner to consider the consequences of alternative management opportunities. Illustrations of this concept are given in several Notes that follow.

John W. Moser, Jr.
Department of Forestry and Natural Resources
Purdue University
West Lafayette, Indiana