446

# ISSUES AFFECTING THE INTERPRETATION OF EASTERN HARDWOOD RESOURCE STATISTICS

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ABSTRACT

Forest inventory statistics developed by the USDA Forest Service are used by customers ranging from forest industry to state and local economic development groups. In recent years, these statistics have been used increasingly to justify greater utilization of the eastern hardwood resource or to evaluate the sustainability of expanding demand for hardwood roundwood and sawtimber. This paper examines Forest Inventory and Analysis (FIA) statistics and demonstrates how they can be misinterpreted. In some cases, the total fiber supply can be underestimated because cull trees are not included in estimates of growing stock and sawtimber. In other cases, the use of annualized growth and removal statistics overestimates sustainable harvest levels. Forest researchers and others using FIA data should determine the meaning of inventory statistics for the state and products under study before assessing the degree of sustainability resulting from increased demand by primary forest products manufacturers.

One of the primary functions of the USDA Forest Service Research branch is to conduct periodic estimates of timber inventories in the nation's forest resources through the Forest Inventory and Analysis (FIA) program. Currently, forest inventories are conducted by five regional FIA work units associated with the five Forest Service Research Stations. The statistics developed by these units are used by 1) forest researchers to assess changes in forest structure and composition and forest health; 2) forest industry to assess the availability of fiber and sawlogs; and 3) state and local governments to attract primary and secondary wood products manufacturers.

An examination of FIA statistics reveals that while softwood sawtimber volumes have remained relatively constant between 1977 and 1992, the volume of hardwood sawtimber has increased by 50 percent (11). Total hardwood growing-stock volume has increased by a more modest 26 percent, but this is still better than softwood growing stock, which has decreased by nearly 4 percent (11). In addition to declining softwood growing stock, much of the softwood timber base has become unavailable to industry because of the reduction in timber sales from western National Forests.

The expansion in hardwood timber volumes and the decline in softwood availability have caused industry to examine the use of eastern hardwoods to satisfy consumer demands for solid and fiber-based wood products. In turn, these changes have caused increased reliance on FIA statistics concerning the hardwood timber base. However, what we term as hardwood and softwood are different plant forms that have regenerated under differing conditions, and inventory statistics of these two plant forms may not be directly comparable. Therefore, it is critical that users of hardwood inventory information understand the details of these statistics.

In this paper, we examine the methods and accounting procedures used to develop forest inventory statistics. Of specific interest is the meaning of "growing stock and sawtimber" and the interpretation of "annualized estimates of growth and removal" and how these terms differ between hardwoods and softwoods.

## THE DEVELOPMENT OF INVENTORY STATISTICS

Estimates of timber inventories are developed using a two-phase system. Phase one uses a sample of aerial-photos to estimate the proportion of forest land by county. During phase two, detailed field measurements are taken on randomly selected plots. Individual tree measurements include diameter at breast height (DBH), bole length, sawlog length, cull percent, and tree grade. These measurements form the basis

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of equation-based estimates of the cubic-foot and board-foot volume of individual trees (12,13). A subset of the phase-two sample consists of remeasured locations that provide paired measurements for estimating average annual components of change: net growth, removals, and mortality. Final estimates of forest inventory are developed by combining acreage information developed in phase 1 with plot information developed in phase 2.

The definition of "growing stock" includes trees of commercial species that are at least 5.0 inches in DBH. Trees are considered sawtimber size if they are softwoods at least 9.0 inches DBH or hardwoods at least 11.0 inches DBH. To qualify as growing stock, sawtimber size trees must contain at least one 12-foot sawlog or two noncontiguous 8-foot sawlogs. Trees less than sawlog size must have the potential to contain the required sawlog(s) when they attain sawtimber size. Additionally, one-third of the sawlog portion must be free from defects, such as rot or poor form. In assigning volumes to growing-stock trees, any cull portions of the merchantable bole or sawlog are deducted, hence the term "net volume."

The definition of growing-stock arose from industry's specification for stumpage and the concept of the manageable stand. As such, it represents trees preferred by managers and would be retained following a management operation, such as thinning. Trees not considered as growing stock include "rough" and "rotten" stems. Rough trees do not contain a sawlog or potential sawlog primarily because of sound cull such as limbiness or sweep. Rotten trees do not contain a sawlog or potential sawlog primarily due to unsound cull portion.

The rough-tree designation also includes "noncommercial" tree species. Some examples are boxelder, striped maple, American hornbeam, and persimmon. However, what is deemed a noncommercial species can vary from state to state. Rough and rotten trees are commonly referred to as "cull trees." The primary causes of cull trees in hardwood stands are poor sites and damage caused by fire, disease, and insects. Hardwood forests generally have a much higher proportion of cull trees than softwood forests. One reason for this is that hardwood trees are seldom destroyed by fire, though their butt logs usually are damaged.

Increase in gross growing stock or sawtimber volumes is the sum of ingrowth, accretion, and cull increment/decrement. Growing-stock ingrowth consists of trees that have grown to the 5-inch merchantable threshold since prior measurement. Similarly, hardwood sawtimber ingrowth occurs when trees less than 11 inches in DBH cross the threshold to sawtimber size. Accretion is the increase in volume of trees already in the growing stock or sawtimber inventory. Cull increment/decrement represents the net difference between the volume of trees entering and departing the cull-tree class. For inventories conducted over the last decade, the volume of trees previously classified as cull trees that are subsequently reclassified as growing stock (cull decrement) has far outweighed the volume of trees that become cull (cull increment). This reclassification has resulted from a gradual change in the definition of growing stock.

Net growth of growing stock and sawtimber is defined as gross growth minus mortality. Mortality trees are those that have died since prior measurements. However, there are subtle differences in mortality estimates between and among FIA units.

The FIA unit at the USDA Northeastern Research Station estimates mortality volume using tree measurements from previous inventories. There is no attempt to account for growth that occurred between the previous measurement and the actual time of death. The North Central and Southern Research Stations FIA units record estimated time of death, allowing tree growth to be simulated when mortality volume is estimated.

Net change in growing-stock and sawtimber volume is equal to net growth minus timber removals. Timber removals are estimated by accounting for trees harvested since the previous inventory. Another form of timber removal is timberlands that shift to other land uses. All of the volume of trees on land that changes land use is included in estimates of timber removal. As with mortality, the Northeastern FIA unit does not attempt to compute growth on removals, while the North Central and Southern units estimate growth prior to removal.

It is noteworthy that some mixing of mortality and removals occurs in FIA statistics when a tree dies and is salvaged between inventories. In this case, the volume usually is assigned to timber removals rather than mortality. The confounding of mortality and removals usually is considered negligible, but it can be significant following large mortality events, e.g., the gypsy moth infestations of the 1980s.

The often-used estimates of average annualized growth and removal are calculated by dividing total net growth or removals since the prior survey by the number of years between surveys. Such estimates represent the period between successive inventories rather than a given year.

## Interpreting Inventory Statistics

It is critical that users of FIA information understand definitions, compilation procedures, and possible pitfalls relating to the resource questions they are analyzing. The concept of growing stock and the derivation of average annual growth and removals are common sources of misinterpretations.

Problems can arise in interpreting FIA statistics if users take a narrow view that growing-stock inventories are fully representative of forest resources. This will cause users to underestimate timber availability, particularly if the intent is to examine total fiber availability. The volume of cull trees should be considered as part of the overall fiber resource. In Pennsylvania, the most recent inventory included nearly 1 million ft.$^3$ of cull-tree volume (1). Missouri's most recent inventory showed an extremely high proportion of hardwood cull trees with 45 percent of the sawtimber-size hardwood reported to be cull (7).

The percentage of cull trees also changes by tree diameter. As **Figure 1** indicates, the percentage of cull hardwoods in West Virginia decreases as diameter increases but reaches a low point and then increases. The high percentage of cull trees in the largest diameter classes likely represents a buildup of "wolf trees" that have been repeatedly passed over by loggers. The U-shaped curve representing the percentage cull by diameter class is common for most eastern states. A major exception is Missouri, where the percentage of culls increases with diameter.

In addition to cull trees, there is potentially a considerable volume of hardwood fiber contained in cull portions, tops, and limbs. However, the recoverable amount of fiber from these sources is a function of the type of technology used to transform timber into chips. The greater the degree of whole-tree chipping and off-site chipping, the greater the potential that cull portions, tops, and limbs are used. Also, new technology being employed at oriented strandboard plants can use crooked sections such as limbs.

The FIA information on change components also should be scrutinized carefully. The reclassification of cull trees as growing stock can have a significant impact on estimates of net growth. To illustrate, West Virginia's 1989 inventory reported cull decrement that was 12 percent of the net growth of growing stock compared to 16 percent for ingrowth (5). Cull decrement can vary considerably by species. In West Virginia, cull decrement was 20 percent of the net growth for other white oaks (mostly chestnut oak), but only 3 percent of the net growth of yellow-poplar.

Another concern related to change components is the "snapshot" nature of annual estimates of growth and removals. Annual estimates are simply averages for the period between inventories. Although they do not necessarily reflect the current conditions, they often are interpreted as such. This can lead to serious misinterpretation because growth, removals, and mortality vary over time. Growth changes as levels of accretion and ingrowth fluctuate. In recent decades, hardwood forests of the East have matured gradually. Ingrowth to sawtimber has been especially high as hardwood trees have grown to the 11.0-inch threshold. In the future, the level of ingrowth will decline as a greater percentage of the growing stock exceeds 11.0 inches.

Since the relationship between growth and removals is often used to gauge resource sustainability, it is important that these estimates be interpreted correctly. The tendency for the Northeastern FIA unit to underestimate net growth by not accounting for growth on removals should be noted when analyzing these data. Analysts also should consider that future increases in sawtimber inventory probably will be more moderate than in the past.

It also is important that analysts understand the relationship between periodic averages and trends in annual removal levels. In regions where timber removals are increasing, FIA removals likely will be lower than single-year estimates of timber production for years towards the end of the period. In this situation it is particularly important that average annual estimates not be extrapolated to estimate future demand.

**Table 1** compares FIA estimates of average sawtimber removals for 1961 to 1974 and 1975 to 1989 (3,5) with estimates of sawtimber production for West Virginia for 1965, 1974, 1987, and 1994 (4,15,16). As shown, estimated production of sawtimber reported in the TPO studies is higher than estimated average removals. The explanation for this is that FIA sawtimber removals are for the sawlog portion of hardwood at least 11.0 inches in diameter. The annual surveys include removals of sawtimber volume in trees less than 11.0 inches, cull trees, and non-sawlog portions. There are many sawmills in West Virginia that produce pallet stock and other products from non-sawtimber material. The considerable increase in sawtimber removals in West Virginia during the late 1980s is also shown in **Table 1**. It is safe to assume that the margin between the FIA average estimate for 1975 to 1989 and annual removals for later years has continued to expand.

Finally, the interpretation of FIA statistics for timber availability should be augmented with information from other sources. Actual availability of timber depends on factors such as owner attitudes, accessibility constraints, and operability limits. To illustrate, a recent study of owners in West Virginia reported that 36 percent of the private forest land owners who controlled 10 percent of the forest land indicated they would not harvest timber during the next 10 years (2).

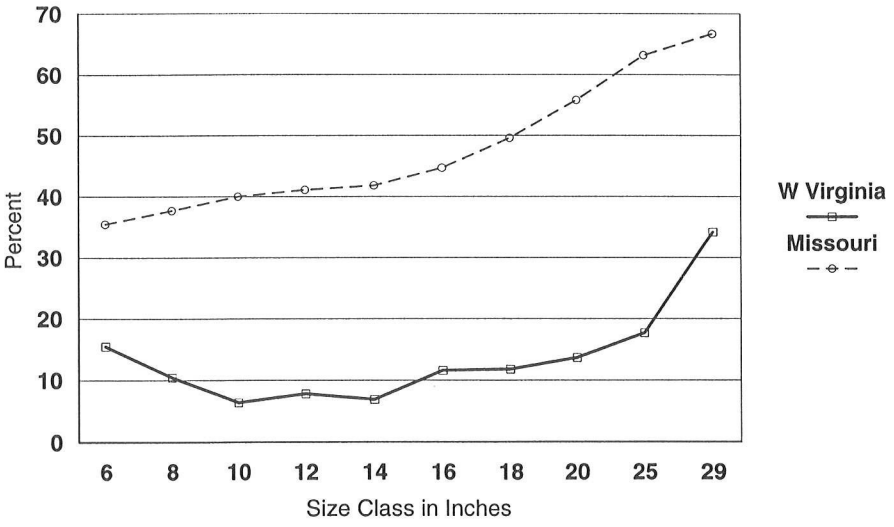


Figure 1. — Percentage of all live trees classified as cull by diameter class in West Virginia and Missouri 1989 (developed from 5 and 6).

*TABLE 1. — Estimates of hardwood sawtimber removals and sawtimber production for West Virginia (developed from 3-5,15,16).*

| Survey period | Average annual sawtimber removals | Reporting year | Estimated sawtimber production |
|---|---|---|---|
| | (MMBF) | | (MMBF) |
| 1961 to 1974 | 405.3 | 1965 | 470.5 |
| | | 1974 | 446.4 |
| 1975 to 1989 | 411.4 | 1987 | 556.0 |
| | | 1994 | 794.4 |

Although this discussion is relevant for the FIA inventory information that is currently available, there are plans to make changes in the frequency of inventories. Following the direction of a number of national client groups, the U.S. Congress passed authorizing legislation in 1998 that established a mandate for FIA to convert from a periodic inventory system to an annual system (6,14). The legislation and other national policy decisions have essentially created a new approach for quantitative assessment of forest condition, health, and sustainability of the nation's forests. Major features of the new approach include a new field sample-location design, a requirement to measure 20 percent of all field samples annually, and the merger of FIA with the Forest Health Monitoring (FHM) program. The FHM samples are now being used as a new phase three of the FIA design. The new system is referred to as the "enhanced" FIA program and is being implemented nationwide to provide seamless estimates across the five FIA regions. Each of five regional FIA units are now in the process of converting to the new system and each faces a unique array of challenges because, in the past, each region has used different approaches to the periodic inventory system.

## Implications and Conclusions

This paper examined the development of some of the most often used FIA inventory statistics and discussed how these statistics can be misinterpreted. One of the most active areas in the hardwood industry is increased fiber demand by pulp and engineered wood products manufacturers. Estimating the impact of these demands on the resource should not be based solely on growing-stock volume but the usable fiber volume from all sources including culls, cull portions, tops, and in some cases, limbs. It also should be noted that the proportion of live trees that are cull usually is greater in hardwoods than softwoods.

If estimates of annualized growth and removal are taken out of context, a false impression that new industry can be supported will emerge. Over the last 20 years, much of the increase in growing-stock volume has been the result of accretion, while most of the increases in sawtimber resulted from ingrowth. Cull decrement also has been a source of increased growing-stock volumes in some states. As the resource ages, increased sawtimber volume will come from accretion and decreased volumes will result from ingrowth, thus potentially slowing net growth. Only if larger diameter trees are allowed to increase to their maximum mean annual increment can we expect accretion to support increased sawtimber demand.

The growth in sawmill size is an indicator that existing industries in hardwood-producing states have adjusted to the increased sawtimber volumes (8-10). Encouraging new industrial expansion at a time when sawtimber production by existing firms is increasing and ingrowth may be decreasing could result in an unsustainable situation. This does not mean that our eastern forests cannot sustain additional demand, but that one must be careful when analyzing the impact of potential new demands. Ignoring the finer aspects of FIA statistics by declaring there are countervailing biases in the numbers may result in erroneous conclusions.

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