United States
Department of
Agriculture

Forest Service

**Southern Forest
Experiment Station**

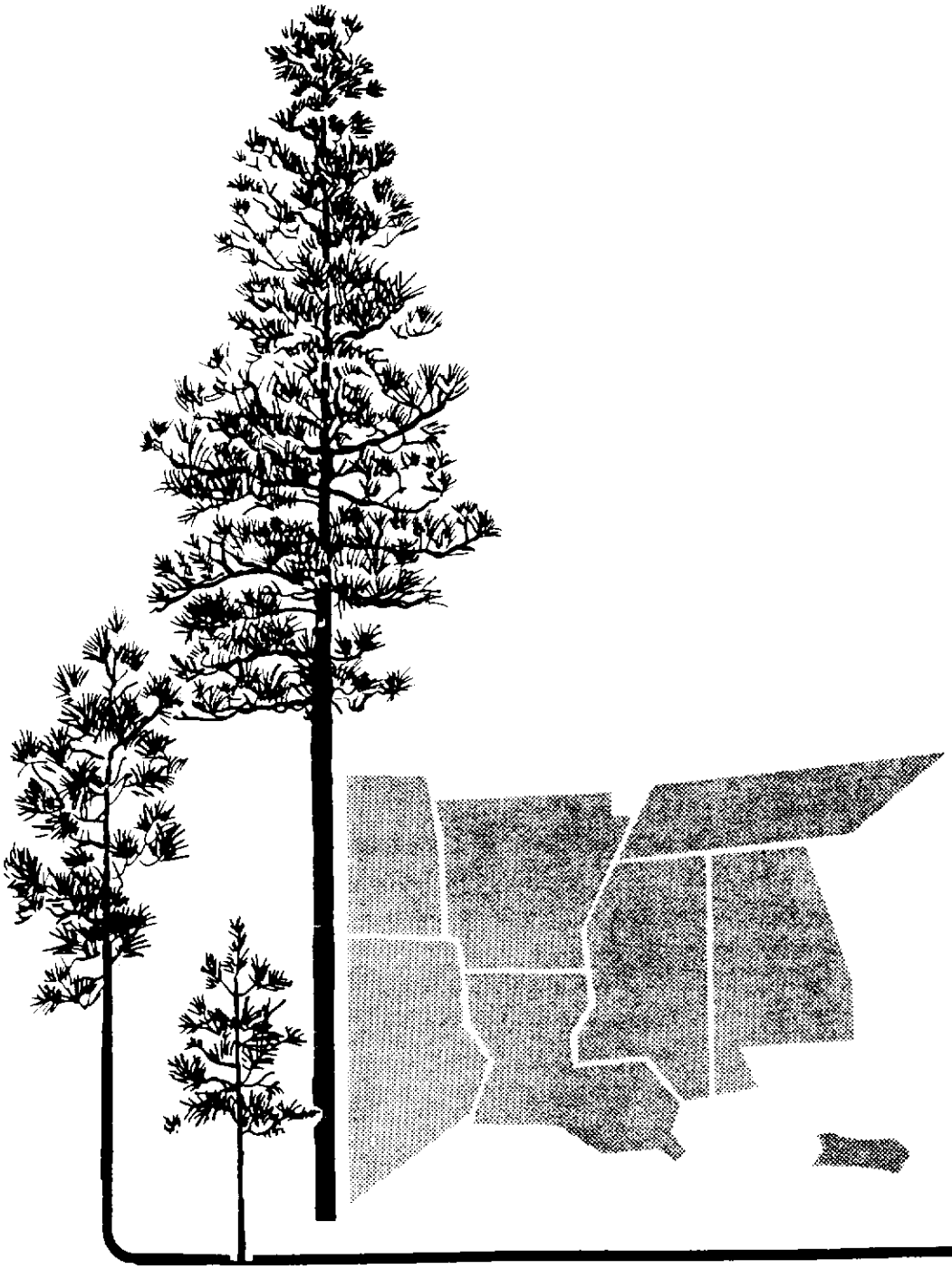
New Orleans,
Louisiana

Proceedings Reprint

THE USE OF AERIAL PHOTOGRAPHS AND ANGLE-GAUGE SAMPLING OF TREE CROWN DIAMETERS FOR FOREST INVENTORY

Gering, Lawrence R.; May, Dennis M.; Teuber, Kurt B.

In: State-of-the-art methodology of forest inventory: a symposium proceedings; 1989 July 30-August 5; Syracuse, NY. Gen. Tech. Rep. PNW-263. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station: 286-289.



Southern Forest Experiment Station

The Use of Aerial Photographs and Angle-Gauge Sampling of Tree Crown Diameters for Forestry Inventory

Lawrence R. Gering
Assistant Professor of Forest Biometrics
School of Forestry
Louisiana Tech University
Ruston, LA 71272

Dennis M. May
Kurt B. Teuber
Research Foresters
Southern Forest Experiment Station
USDA Forest Service
Starkville, MS 39759

ABSTRACT

The Forest Inventory and Analysis unit of the Southern Forest Experiment Station is charged with conducting continuous inventories of the forest resources of the Midsouth. Techniques that offer innovative approaches for improving the efficiency of these inventories are in demand. One new approach for estimating the density of forest stands involves the derivation of a technique for obtaining stand density from aerial photographs based on the principles of selection with probability proportional to size. This is accomplished by the development and use of an aerial-photo angle-gauge that is used in a procedure very similar to the ground point-sampling technique proposed by Bitterlich (1948).

Various aspects of this method have been investigated by McTague (1988) and Gering and McTague (1988); they concluded that further research is needed to compare this method of forest inventory with the traditional ground-based methods for areas in the South. The purpose of the study reported here was to compare the results of an inventory based on the angle-gauge method with those of a ground-based inventory conducted by the Forest Inventory and Analysis unit for one county in the Midsouth.

INTRODUCTION

Continuous forest inventories of the Midsouth are conducted by the Forest Inventory and Analysis unit of the Southern Forest Experiment Station. Techniques that offer new and innovative approaches for improving the efficiency and accuracy of these inventories are in demand. Procedures based on remotely sensed data may fulfill this need by improving the timeliness of current ground-based forest surveys and by allowing efficient data collection in geographically remote locations (such as west Texas and Oklahoma).

The ability to obtain reliable measurements of forest stand characteristics from aerial photographs has long been recognized by both researchers and practicing foresters. However, the use of remotely sensed data often has been limited to providing descriptions of land cover in the form of maps and summary statistics. Smith (1986) noted that the concept of estimating quantitative forest stand characteristics from aerial photographs has not yet reached its fullest potential.

One approach for estimating the density of forest stands was recently introduced by McTague (1988). It involved the derivation of a technique for obtaining stand density from aerial photographs based on the principles of selection with probability proportional to size. Results of his study included

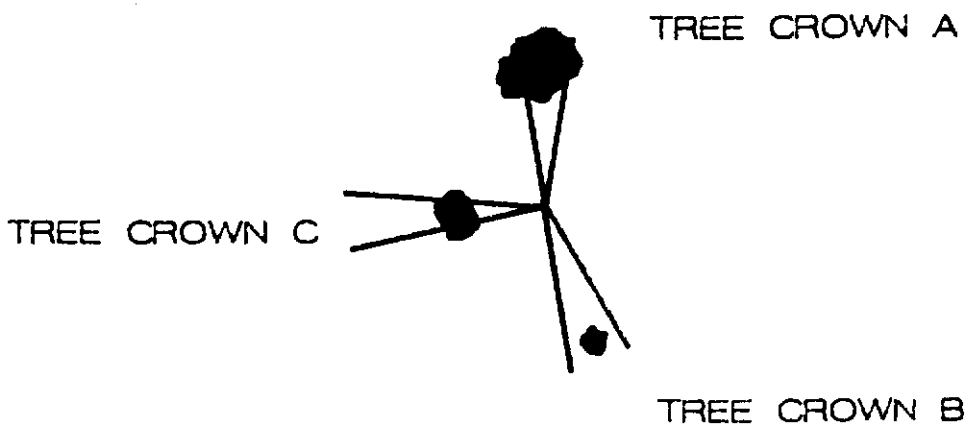


Figure 1. The crowns of trees A and C subtend an angle larger than that of the angle-gauge. Stand basal area (sq ft/acre) = (2 x BAF).

the development of an aerial-photo angle-gauge that is used in a procedure very similar to the ground point-sampling technique proposed by Bitterlich (1948) and now widely used by foresters. For the photo-based method, the angle-gauge, printed on transparent film, is rotated 360 degrees about the point center on the photograph and a count is made of all tree crowns that subtend an angle larger than that of the angle-gauge (Figure 1). McTague concluded that this method of estimating stand density is suited to the ponderosa pine (Pinus ponderosa Engelm.) type of northern Arizona.

In another study, Gering and McTague (1988) calculated the dimensions of an aerial-photo angle-gauge for estimating stand density from aerial photos of loblolly pine (Pinus taeda L.) sites in northern Louisiana. They concluded that the procedure appears to have great potential because it is quick, relatively simple and eliminates direct measurements of plot areas or tree dimensions. They also noted that more research was needed to compare this method of estimating forest inventory with the traditional ground-based methods used for areas in the Midsouth.

The objective of this study was to construct angle-gauge(s) based on the data and statistical correlations for ground-measured tree and stand variables (particularly crown width to dbh) for west-central Tennessee (Hardin County). The angle-gauge sampling technique was then used to inventory a second west-central Tennessee county (Wayne County); these results were then compared with those obtained from the ground-based inventory conducted by the U.S. Forest Service.

METHODS

Aerial photographs of west-central Tennessee (Hardin and Wayne Counties) were flown in the Fall of 1988. Color prints (with a nominal photo scale of 1:4800) were provided to crews from the U.S. Forest Service who were collecting ground-plot data during the Tennessee re-survey. Each sample point was located on the photographs and baselines were established for scale determination and photo orientation.

There were 37 plot clusters (10 sample points per cluster), with corresponding photographic coverage, established in Hardin County. All 370 sample points have been identified on the aerial photographs; this was a relatively easy task because of the uniform plot layout used by the field crews. Individual tree crowns were also identified on the photos and assigned a code number which corresponded to the tally sheets containing the ground-measured data. Crown widths were estimated using a 7x-power monoscopic comparator with a recticle illustrating circular diameters. Measurement units were converted to feet using the exact photo scale (as determined using the established baseline).

Data from Hardin County were used to develop correlations based on ground-measured dbh and photo-measured crown width. These correlations enable the construction of the angle-gauges, using established techniques, for forest stands located in west-central Tennessee.

A second west-central Tennessee county (Wayne County) has similar terrain and vegetative cover as the adjacent Hardin County. A forest inventory of Wayne County will be conducted based on aerial photographs and samples obtained using the angle-gauge(s) developed for forest stands of west-central Tennessee. By doing this, the angle-gauge(s) will not be tested against the data from which they were developed. The results of this inventory will be compared to the results of the more traditional ground-based inventory.

DATA DESCRIPTION

Previous work on angle-gauge sampling (McTague, 1988; Gering and McTague, 1988) was based on the sampling of a single tree species. This study, however, is concerned with the forest resources of an entire county and is not limited to a single tree species. Hardin County data included 748 live trees representing 5 coniferous species, predominantly loblolly pine (Pinus taeda L.), and 37 deciduous species, predominantly oak (Quercus spp.), American beech (Fagus grandifolia Ehrh.) and hickory (Carya spp.). There are also two categories of stand size class (pole and sawtimber) and three categories of crown class (dominant, codominant and intermediate).

The importance of sorting the data into similar classes prior to developing correlations becomes evident. Initial species sorting has been based on 4 general forest types: loblolly-shortleaf pine, oak-pine, oak-hickory, and oak-gum-cypress. Sorting within these forest types has also been done by stand size class and crown class. Additional categories, based on a single-species grouping such as oak or loblolly pine, have also been created by sorting the data set. As a result of the sorting, 30 separate data categories have been created and correlations between ground-measured dbh and photo-measured crown width have been developed.

The next phase of the study will be to analyze the correlations and determine whether any or all are significantly different. The goal is to minimize the required number of angle-gauges. Ideally, a single angle-gauge would be suitable for all species and classes. However, the likelihood of this result is small. Hopefully, a reasonable number (perhaps 3 or 4) of different angle-gauges will be able to adequately sample aerial photographs of west-central Tennessee.

A similar study for two parishes in northern Louisiana (Claiborne and Union Parishes) has also been established. This second study is based entirely on field-measured data (suitable photographic coverage is not available) which represent 1319 trees. Correlations for data groupings are also being developed and analyzed. A comparison of the angle-guages for Louisiana and those for Tennessee will be made to determine if significant differences are present. This will indicate whether an angle-gauge developed for a given set of conditions is valid over a broad geographic range or if it is suited only for a limited area.

CONCLUSION

Obviously, the study reported here has not yet been completed. The logistic problems of coordinating data collection by several different methods and joining the data for analysis and comparison have delayed this project. Rather than a review of partially completed work, the intent of this paper has been to describe an inventory technique, based on simple aerial photographs, that may interest both research- and field-oriented foresters. The angle-gauge sampling technique is conceptually sound and application is relatively simple. However, any decision concerning future use of this technique must consider the comparison of the angle-gauge inventory with the traditional ground-based inventory, as established in this study.

REFERENCES

Bitterlich, W. 1948. Die Winkelzahlprobe. Allgem. Forest-u, Holzw. Ztg. 59 (1/2):4-5.

Gering, Lawrence R. and McTague, John Paul. 1988. Estimating stand density of loblolly pine in northern Louisiana using aerial photographs and probability proportional to size. In: Technical Papers of 1988 Annual Convention of the American Society for Photogrammetry and Remote Sensing; Vol. 4: 222-228.

McTague, J.P. 1988. Estimation of stand density with probability proportional to size from aerial photography. West. J. Appl. For. 3(3):89-92.

Smith, J.L. 1986. Evaluation of the effects of photo measurement errors on predictions of stand volume from aerial photography. Photo. Eng. and Rem. Sens. 52:401-410.

ACKNOWLEDGEMENT

The authors would like to express their thanks to Catherine C. Taylor and Lee Reynaud, undergraduate students in the School of Forestry at Louisiana Tech University. This study was supported by as a cooperative research project between the USDA Southern Forest Experiment Station and Louisiana Tech University. Additional funding was provided by the McIntire-Stennis Cooperative Forestry Research Program under Public Law 87-788 and the State of Louisiana.