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N78-14597

ASSESSMENT OF FOREST PLANTATIONS FROM LOW ALTITUDE AERIAL PHOTOGRAPHY

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SUMMARY

Vertical color, and color-infrared, aerial photography obtained from altitudes between 183 m and 915 m provide a cost-effective method of determining tree survival and height growth in pine plantations on the North Carolina Coastal Plain. All interpretations were performed by professional forestry personnel from the original 70 mm. color transparencies.

Prompt assessment of tree survival is necessary if failed spots are to be successfully replanted. Counts of living trees made after the third growing season, and sometimes only two growing seasons after planting, are accurate enough to permit planning of replanting operations without extensive ground surveys.

Using a Bausch and Lomb Zoom 70 Stereoscope and a narrow-span Parallax Bar built by Charles A. Hulcher, Inc., tree heights were measured without cutting individual frames from the roll. Errors in relative orientation that resulted from this procedure were acceptable, and individual tree heights were determined within plus-or-minus 0.30 m of the corresponding ground measurement, approximately ninety percent of the time, when photographs were taken three or more growing seasons after planting.

Cost of photographic assessment of plantation survival and height growth is substantially lower than for traditional ground methods. The aerial vantage point also permits more complete sampling and evaluation of each plantation, with fewer omission errors, than when solely ground methods were used.

INTRODUCTION

Effective management of forest plantations requires substantial amounts of timely information relative to tree survival, stocking levels and tree heights. In the southeastern United states where forest plantations are grown on relatively short rotations of 20-25 years time is a critical economic consideration. Rapid changes resulting from forest management activities make photo coverage of total ownerships at medium photo scales, and at periodic intervals of four to five years, inadequate to meet the needs of intensive plantation management. Replanting of failures, establishing priorities for precommercial thinning, commercial thinning, fertilization, monitoring growth and predicting yields at rotation age all require current information. Early identification of site and stand problems is essential to their prompt correction.

In 1976 Weyerhaeuser Company examined the potential use of large scale vertical, color, aerial photography to obtain certain information needed for its High Yield Forest Program. Work was conducted in the coastal plains of eastern North Carolina where much of the forest land is characteristically flat, with high water tables, and where artificial drainage is a major preplanting site treatment. Plantation failures are normally spotty segments within a whole plantation and are frequently associated with wetter areas.

STUDY OBJECTIVES

The primary objective of the study was to determine the capabilities of making tree counts in plantations two and three years after establishment. Priorities were placed on these ages because corrections, namely replanting, within these ages offer the greatest opportunities to maintain even-aged stands that can be managed and harvested as such; thus minimizing future management problems inherent with patchy age class distributions on the ground.

A second objective was to determine the capabilities of measuring tree heights in three year age classes. Tree heights are an important variable in growth and yield predictions.

METHODS

Vertical photography was obtained with a Hulcher Model 103 Sequence Camera with a 70 mm film format and equipped with a 152 mm focal length lens. Target photo scales for all studies was 1:1200. Variations in actual photo scales range from 1:1068 to 1:1224. Normal color reversal film, Kodak Emulsion 2448, was used in each study.

All interpretations were made from the originally exposed 70 mm film used with a Bausch and Lomb Zoom 70 Stereoscope mounted on a specially made light box and film transport system (Fig. 1.). Tree heights were determined from parallax measurements made with a narrow span parallax bar designed for use under the Zoom 70 Stereoscope without cutting film into separate frames (Figs. 2. and 3.).

Tree Counts

Tests to determine tree count reliabilities were conducted in two and three year old loblolly pine (Pinus taeda) plantations. A series of markers placed on the ground prior to photography were clearly visible in the photographs and were used as centers of circular photo plots 5 mm in diameter. These markers, 30.5 meters apart in the three year old plantation and 15.3 meters apart in the two year old plantation were also used to determine actual photo scale. Living pine trees detected in the photography were tallied and their locations indicated on a plot diagram. This was followed by an actual ground count on identical plots whose diameters were calculated from actual photo scale. Tree heights were also measured in the ground check. The photo interpreter was not present during the ground count. This procedure permitted comparisons of the photo counts with ground counts on an individual tree basis and provided a means of determining the source of error.

Tree Height Measurements

Tree heights were determined from stereo-parallax measurements of 183 trees in one three year old loblolly pine plantation. Trees had been planted 1.8 m apart on beds, ridges about 0.20 m higher than the ground level in the alleys between the beds. Beds, and hence tree rows, were 2.75 m apart and the alleys had been moved. Ground markers were used for location references and to calculate tree flying altitude. Again a diagram showing and numbering each tree presented a tree-by-tree comparison of true ground heights with photo measurements.

Four photo measurement trials were completed. Base readings were consistently made midway in the alleys between beds (tree rows), but at different frequencies from trial to trial.

Trial 1: One base reading was made for groups of four trees. About one half of the top readings were taken on the sunlit sides of the tree and about one-half on the partially shaded side. Measurements were made at 7X magnification.

Trial 2: One base reading was made for each tree. Top readings were consistently taken on the sunlit side of the tree top and magnification was increased to 10X.

Trial 3: Similar to trial two except that one base reading was made for groups of seven to ten trees in a row.

Trial 4: Similar to trials two and three except that one ground reading was made for groups of 35-50 trees in all directions around the point of the ground reading.

RESULTS

Tree counts made from large scale, vertical, color aerial photography identified 96 and 97 percent of the trees found in identical ground plots in two and three year old loblolly pine plantations, respectively. Omissions during photo counts were confined to the smaller trees under about one meter in height at the third year and under about one-half meter at the second year (Figs. 4. and 5.).

Tree height measurements from large scale color photography at three years age was consistently within 0.36 m of the actual ground mean. The largest errors were found in the first photo trial, and other trials gave essentially the same results with mean photo measurements being consistently within 0.16 m of actual mean height (Fig. 6.).

DISCUSSION AND CONCLUSIONS

The study results of both tree count and height measurement tests are within the accuracies required for operational purposes.

Tree Counts

Tree counts are considered well within the accuracies required. From a practical standpoint, trees missed in the photo count are considered insignificant; they will either die before rotation age is attained or will be suppressed trees contributing little volume to the mature stand.

Tree size per-se is not necessarily the only factor governing detection in photography. Numerous trees were identified that were smaller than several trees that were missed. A main factor is the relation of a tree to the surrounding grasses and herbaceous growth.

Photography for these studies was done during the dormant season when competing herbaceous growth was largely defoliated. The brush and dead grasses were still there however. Experience in similar plantations with similar photography during the summer growing season strongly suggests that this work need not be confined to the dormant season. In fact, photographing during the growing seasons could be advantageous in evaluating the competition and prescribing early treatment needs for its reduction.

Tree Heights

Tree height measurements were within the 10% of mean height accuracy required. While measurements in this study covered a total height range from 0.80 m to 2.5 m, only heights of dominant trees would be measured for operational purposes.

The bias towards higher photo height measurements than actual ground measurements was consistent and largely due to the fact that ground readings were taken from the photos midway in the alleys between the tree rows. Actual ground height measurements, however, were taken from the base of the trees at the tops of the beds. The beds were uniformly about 0.20 m higher than ground levels in the alleys. This difference in ground levels between alley bottoms and bed tops is slightly more than the indicated measurement error. Corrections for bed heights are easily made and when the correction is made, the mean tree heights measured from the photos is found to be slightly lower than the actual mean height (Table 1).

There was some tendency toward larger errors with the very smallest trees with photo measurements being less than actual tree heights. A likely reason for this is that many smaller trees have a pronounced single growth terminal which is not clearly resolved on film. Thus, top readings are likely to be made in a lower portion of the tree. In larger trees of the same age lateral branches grow upward forming some crown diameter nearer the tree top which is more clearly resolved on film. This point is not considered particularly significant because only dominant tree heights are measured for operational purposes.

Trials three and four were designed to more closely simulate actual situations where tree crowns frequently obscure much ground vision and good ground readings cannot be made for each tree measured. The results of these trials demonstrates that a ground reading is not necessary for each tree in relatively flat terrain when the photos are obtained with a 70 mm film format and a 152 mm lens.

ACKNOWLEDGEMENTS

The writer gratefully acknowledges helpful suggestions through personal conversations with Dr. C.E. Olson, University of Michigan, Dr. A.H. Aldred and staff, Canadian Institute of Forest Management and thanks to Dr. N.E. Johnson, George Staebler, R.M. Wiggins, A.R. Hollowell, and R.A. Hansen, Weyerhaueser Company, for their support.

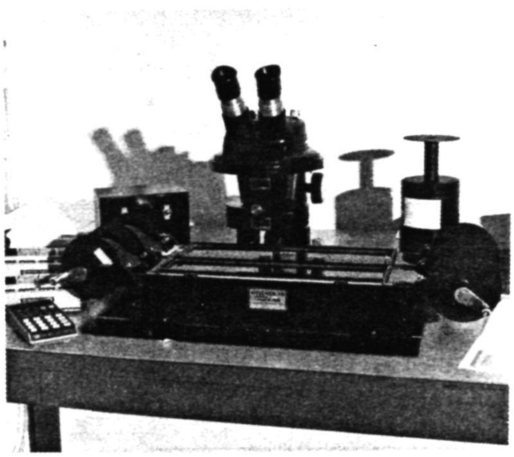

Figure 1. Illustrates the light box and film transport system used with the Bausch and Lomb Zoom 70 Stereoscope. The stereoscope is stationary, but the box has x and y travel to maintain stereo vision over the full stereo pair. The system carries two strips of film to accomodate films resulting from a dual camera system not discussed here. Total movement in the x direction is about 229 mm and spans both film strips in the y direction. Light intensities are variable for either film strip.

Figure 2. Illustrates the narrow span parallax bar designed for use under the Zoom 70 Stereoscope without cutting film into individual frames. The plates with dot marks protrude from both sides to permit measurements on either side or in the center of the film. The digital micrometer is used to facilitate reading and minimize reading errors. The error associated with imperfect alignment of the photos is accepted.

Figure 3. Shows the system in use. The small calculator is programmed to calculate tree heights.

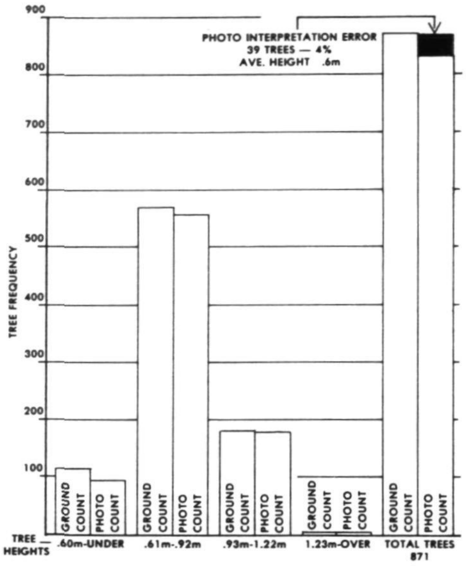

Fig. 4.

Comparison of actual tree counts with photo counts in two year old loblolly pine plantation.

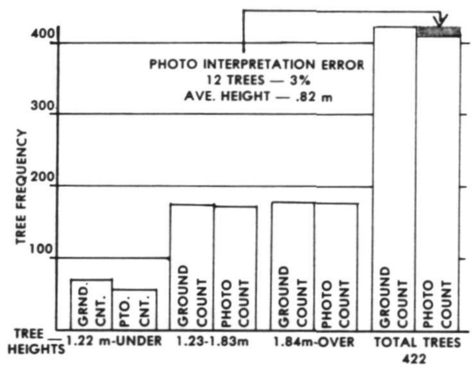

Fig. 5.

Comparison of actual tree counts with photo counts in three year old loblolly pine plantation.

	After second growing season	After third growing season
Photography		
Season	Dormant (March, 1976)	Dormant (Jan. 1976)
Film	Kodak 2448	Kodak 2448
Actual Scale	1:1224	1:1068
Ground cover	Tall grasses and weeds	Tall grasses and brush
Number Plots	40	25
Plot size (Circular	0.01 hectares	0.009 hectares

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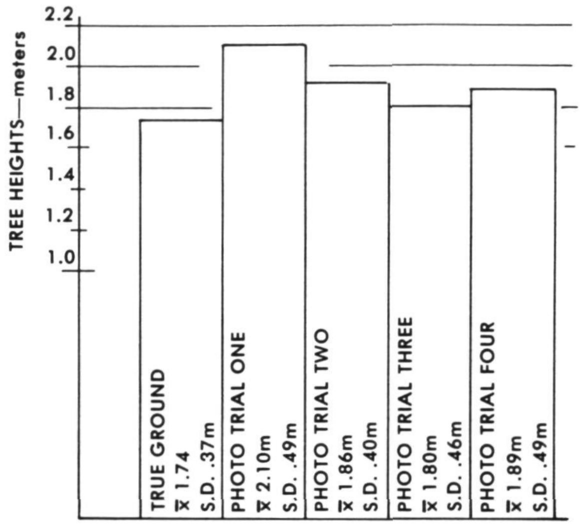

Fig. 6. A comparison of average actual ground height measurements with each of the four photo trials in a three year old loblolly pine plantation.

The increased accuracies in trials two, three, and four are attributed to increased interpretation experience and the increased magnification to 10X, which was maximum without loss of some resolution.

Photography - Dormant season - Nov. 1976
Kodak 2448
Actual photo scale 1:1140
Flying altitude 174 m

	ALL TREES				DOMINANT TREES ONLY			
	No. Trees	Avg. Ht. m	Corrected (-0.20 m)	Error m	No. Trees	Avg. Ht. m	Corrected (-0.20 m)	Error m
Actual Ground	183	1.74			103	2.01		
Photo Trial One	183	2.10	1.90	+0.16(9%)	138	2.29	2.09	-0.08(4%)
Photo Trial Two	183	1.86	1.66	-0.08(5%)	117	2.10	1.90	-0.11(5%)
Photo Trial Three	183	1.80	1.60	-0.14(8%)	96	2.17	1.97	-0.04(2%)
Photo Trial Four	183	1.89	1.69	-0.05(3%)	107	2.23	2.03	+0.02(1%)

Table 1. Comparisons of true ground mean heights with mean heights from each of the photo measurements for all trees and for dominant trees only (trees 1.74 m in height and over). The correction deducts 0.20 mm from photo results to remove the differences due to bed heights referred to in the text.