Laboratory Chief Robert Sporrong, for their generosity in providing the advice and material assistance necessary to accomplish this project. They also wish to express their appreciation to Associate Professor C. J. Shiue of the University of Minnesota School of Forestry for his assistance with the statistical design and analysis.

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*A Test of Polaroid Variable-Color Filters for Forest Aerial Photography**

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ABSTRACT: *Polaroid variable-color filters were used with Tri-X film to examine northern Minnesota conifer-deciduous tree tonal relationships in the green and yellow portions of the reflected spectrum. Although some improvements over summer panchromatic were obtained, the variable-filter photography was inferior to conventional summer infrared minus-blue and fall panchromatic minus-blue photography of the area tested.*

DESPITE trials of a variety of film-filter combinations for forestry photography, only infrared and panchromatic minus-blue have successfully survived the test of repeated field applications. However, neither is ideal under all conditions and each has its own limitations—factors which have encouraged continued search for better film-filter combinations.

It has been illustrated by Colwell[1] that a knowledge of the spectral reflectance characteristics of vegetation, sensitivity range of film, and filter transmission quality permits reasonably valid predictions of photo appearance. Spectral reflectance diagrams of tree species,[2] for example, indicate a wide separation of conifer-hardwood reflectance in the infrared zone, a factor exploited by infrared photography. A secondary zone of conifer-hardwood separation in the 500–600 millimicron zone (green to yellow) is also present. It therefore seemed reasonable to assume that, given a film sensitive in this zone, and a filter capable of screening out the wave-length above and below it, tonal separation of conifers and hardwoods would result. The purpose of the study was to explore this possibility.

Polaroid variable-color filters were selected for use and a special lens mount (Figure 1) was fabricated. Three Polaroid elements, a green and a yellow variable (dichroic) and a neutral linear polarizer, were employed. The color filters were locked into position in the mount and the neutral polarizer placed in a movable ring having an arc of movement

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calibrated so as to produce a "scan" ranging from yellow (setting #1) to green (setting #5). Tri-X film was used due to its greater speed, Super-XX having proven too slow for the low level of light transmittal through the filter.

Comparison of two stages of scan, yellow-green and green-yellow, with fall panchromatic and infrared minus-blue of the same ground area is made in Figure 2. The nearer the scan approached to the green the greater the degree of under-exposure due to the decreasing level of light transmittal. At the same time the images became hazy due, no doubt, to the increasing atmospheric scattering associated with the progressively shorter wave-lengths of light involved. As the scan approached the yellow, the photo-images became sharper, at least in the center of the photographs. As was expected, heavy vignetting took place at the corners of the photographs in all stages of scan due to the thick "stack" of filter elements impeding light passage at the edges. Light transmittal was also reduced in all stages due to the elements not being low-reflection coated.

Conifer-hardwood tonal differentiation with the variable-color filter appeared to be somewhat better than conventional summer panchromatic minus-blue, but considerably below that of either fall panchromatic minus-blue or summer infrared minus-blue of the same ground area in northern Minnesota. As indicated in Figure 2, however, the variable-color filter produced an interesting tonal comparison between spruce-tamarack and pine in that the swamp conifers assumed a very light-gray tone as compared to the dark tone of spruce on fall panchromatic and spruce-tamarack on infrared.

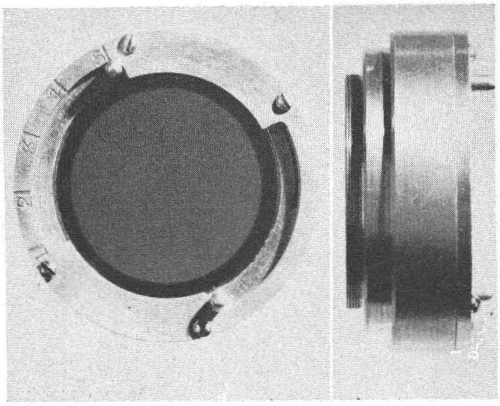

FIG. 1. Top and side view of filter mount.

This study points out the very obvious difficulty of attempting to obtain normal exposure with small portions of the light spectrum on conventional films. In addition, there is a definite limit at which the shorter

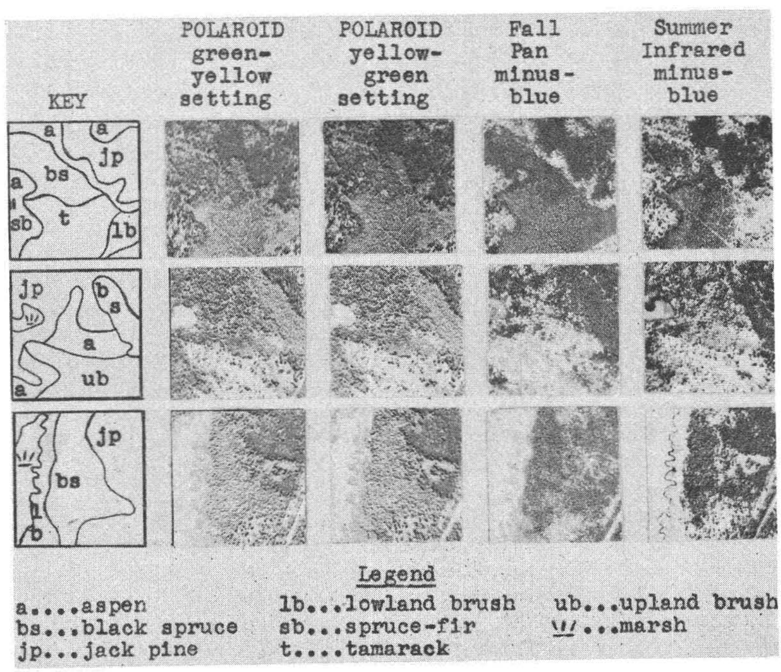

FIG. 2. Comparison of three ground areas at a scale of 1:15,840 photographed with Polaroid green-yellow, Polaroid yellow-green, fall panchromatic minus-blue, and summer infrared minus-blue.

wave-lengths can be utilized without introducing loss of detail. It is entirely possible that high quality absorption-type color filters might be used to produce better photography for forestry purposes, but probably not without a film exhibiting a greater degree and range of sensitivity than that of those currently available.

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Comparative Usefulness of Three Parallax Measuring Instruments in the Measurement and Interpretation of Forest Stands

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ABSTRACT: *The accuracy and efficiency of three simple height-measuring devices are evaluated for forestry use. Records of measurement and elapsed time of five photo interpreters who used these height-finding instruments in measuring forest stands were analyzed in the study.*

INTRODUCTION

DURING recent years, foresters have become increasingly interested in the measurement of tree and stand height by parallax, and in the accuracy of this measurement. Parallax-bars have been compared to parallax-wedges, and both of these to more elaborate measuring devices; usually the differences in accuracy have been found to be nonsignificant. These comparisons have led some forest photo interpreters to assume that any third-order device capable of measuring parallax difference on contact prints is suitable for measuring forest plots, and that selection is largely a matter of personal preference.

The study reported herein, recently completed at the Intermountain Forest and Range Experiment Station, was designed to test the relative value of three photo height-finding devices in routine measurement of forest inventory plots.

EARLY TESTS

Many of the earlier tests were made using height measurements of single trees under conditions rarely experienced by photo interpreters in forest inventory. Spurr (5) states that errors in measurement of individual tree heights by parallax-wedge ranged from 3 to 20 feet on 1:15,840-scale photos of the Harvard Forest. Losee (1) obtained systematic errors of −10 to −16 feet in heights of conifers estimated by a floating-dot parallax device on 1:7,200-scale photos. Worley and Landis (6), using repeated measurements on individual trees made by parallax-wedge and parallax-bar, found no significant difference in the 8- to 10-foot standard errors of estimate obtained by using these two instruments. They stated, however, that interpreters using the parallax-bar seemed to underestimate heights of larger trees to a greater extent than those who used the parallax-wedge.

Studies made using stand measurements by parallax-wedge on randomly distributed 1-acre sample plots have recorded mean errors of 6 to 10 feet on 1:20,000-scale photos of eastern hardwood stands (4), and standard errors of estimate of 5 to 11 feet on 1:20,000- to 1:30,000-scale photos of conifer stands in the Rocky Mountains (2). These studies considered stand measurements by parallax-wedge only; no comparable measurements were made by parallax-bar or other floating-dot device.

Both in forest inventory and in direct photo estimates of volume, photo interpretation of sample plots often requires measurement of crown-diameter and crown-coverage

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