SPECIFICATIONS FOR AERIAL PHOTOGRAPHS USED IN FOREST MANAGEMENT

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AERIAL photographs have already proved to have widespread application in forest management, and will be put to even greater use in this field in the future. Nevertheless, but little information is available as to the types of photograph best suited to forestry use. The needs of the forester differ significantly from those of the photogrammetrist. The forester must be able not only to distinguish the various stands of timber, but also to measure and evaluate them. He requires superior qualities of resolution and tone variation. He must have recent photographs, since old photographs are frequently out-of-date, due to the growth of the trees in the intervening period.

Since forest areas must be photographed at approximately ten-year intervals for most management purposes, and since a superior photograph is needed, the problem of the types of photograph best suited to forestry use is particularly important. The Harvard Forest, in cooperation with a number of other organizations, has undertaken to examine this problem. Experimental strips of photography were taken in the United States through the courtesy of Fairchild Aerial Surveys, Inc., and in Canada by the Royal Canadian Air Force. Photographic materials and advice were supplied by the Eastman Kodak Company and by the Polaroid Corporation. The Northeastern Forest Experiment Station of the United States Forest Service and the Dominion Forest Service of Canada aided in the interpretation of the experimental photographs.

There is a wide choice of specifications for aerial photographs. Among the factors important to the forester are (A) Focal length of lens, (B) Type of photography, (C) Type of print, (D) Season of photographs, (E) Film and filter, and (F) Scale of photography. Of these, the first four were not covered intensively in the present study, but are discussed briefly below because the forester frequently raises questions concerning them.

Various combinations of films, filters, and scales were tried experimentally in widely separated forest areas as detailed in Table 1. Each of the areas photographed was visited to determine what species were present and whether they could be distinguished on the various photographs. Observations were also made of drainage, culture, and other features of the landscape.

In several instances, tree heights, crown diameters, tree counts, and other measurements were made on the aerial photographs and then checked on the ground. These tests gave information on the relative value of different types of photography in quantative forest aerial interpretation. The results of tree height tests are being published elsewhere.[1]

FOCAL LENGTH OF LENS

In all of the tests, with the exception of a single strip, a lens with a focal length of $8\frac{1}{4}$ inches was used. This is the focal length accepted as standard by the U. S. Department of Agriculture, and is well suited for photography at the scales generally preferred for forestry use (from 1:10,000 to 1:24,000). For photography at smaller scales, there is a tendency to use a 6-inch lens. Since, for a given scale, a shorter focal length requires flying at a lower altitude, the effect of using a short focal length lens is to increase topographic displace-

[1] Spurr, Stephen H. and Brown, C. T., Jr. 1946. Tree height measurements from aerial photographs. *Journal of Forestry* (in press).

TABLE 1. EXPERIMENTAL FLIGHT PLAN[1]

Series	Location	Date	Unit	Film	Filter	Scale
A	Cupsuptic Lake, Maine	7/ 1/44	1	XXP[2]	12	1:20,000
			2	XXP	12	14,000
			3	XXP	12	9,000
			4	IR[3]	25	14,000
			5	IR	89A	14,000
B	Petersham, Massachusetts	7/ 5/44	1	XXP	12	1:12,000
			2	XXP	12	6,000
			3	XXP	12	3,000
			4	IR	25	12,000
			5	IR	89A	12,000
			6	XXP	12	Obliques
			7	IR	25	Obliques
			8	IR	89A	Obliques
			9	Kodachrome		1:6,000
C	Plymouth, North Carolina	4/27/45	1	XXP	12	1:23,000
		5/11/45	2	IR	12	23,000
			3	IR	12	18,000
			4	IR	12	12,000
			5	IR	25	23,000
			6	IR	25	18,000
			7	Aero Kodacolor		23,000
D	Lake Baskatong, Quebec	8/20/45	1	XXP	12	1:15,840
			2	XXP	12	10,400
			3	XXP	Aero 1	15,840
			4	IR	25	15,840
			5	IR	25	10,400
			6	IR	12	10,400
			7	Aero Kodacolor		—
E	Cabongo Lake, Quebec	8/22/45	1	XXP	12	1:15,840
			2	IR	25	15,840
F	Akos Lake, Quebec	8/23/45	1	XXP	12	1:18,000
			2	IR	25	17,500
G	Petersham, Massachusetts	9/13/45	1	IR	12	1:18,000
		9/13/45	2	IR	12	12,000
		9/12/45	3[1]	XXP	12	18,000
		8/10/45	4	Aero Kodacolor		17,400
H	Florala, Alabama	10/12/45	1	IR	12	1:15,840

[1] All photographs were verticals unless otherwise indicated. Except for Unit 3 of Series G, which was taken with a 6-inch lens, all photographs were taken with an $8\frac{1}{4}$-inch lens.

[2] Kodak Super XX Panchromatic film.

[3] Kodak Type B Infrared film.

ment, distortion, and apparent depth in the third dimension. If the photographs are to be taken for forestry use, the 6-inch lens should not be used, except over relatively level country. Conversely, over mountainous country, the 12-inch lens should be considered as a possibility.

TYPE OF PHOTOGRAPH

Because the forester is primarily interested in measuring forest areas and forest trees, rather than in mapping large areas at low cost, he has but little use for obliques. In remote areas of low value, such as in northern Canada and Alaska, Trimetrogon coverage or other types of oblique photography may supply the needed forest information. In most cases, however, the forester will use only vertical photographs. The present paper, therefore, deals primarily with vertical photography.

Type of Print

The various types of prints included are (1) contact prints, (2) enlargements, (3) mosaics, and (4) vectographs.

The forest is a three-dimensional structure, and the third dimension is of great importance, as the height of trees is indicative of their age, their volume, and their quality. Most forestry uses of aerial photographs, therefore, *require* a stereoscopic examination of the photographs. Consequently, most foresters work primarily with contact prints.

Enlargements are bulky to handle and difficult to examine stereoscopically. In most cases, examination of contact prints under magnification will yield more information than examination of enlargements made from the same prints. The principal use of enlargements to the forester is for keeping a permanent record of such items as land boundaries, timber sales, and silvicultural operations.

Mosaics are of value to the forester in controlling timber cruises and other forest management operations. Because of the necessity of stereoscopic study, mosaics are only of secondary value, and their use will be determined by their costs, the needs of the forester, and the amount of control available.

Through the courtesy of the Polaroid Corporation, vectograph prints were prepared for both the panchromatic and infrared pictures taken over the Harvard Forest. Vectographs are three-dimensional pictures in the form of a single print constructed from stereoscopic pairs of photographs by the application of the polaroid process. The resulting prints showed slight losses of resolution and tone differentiation.

Apparently vectographs made from negatives of high contrast are entirely satisfactory for forestry work. They are of real value in presenting forestry data to people not accustomed to the use of the stereoscope. For instance, they provide a compact and permanent three-dimensional picture which may be supplied to woods foremen, contractors, and others responsible for the management of forest land.

Season of Photography

Most aerial photography for forestry use must be done while the foliage is on the trees. Photographs taken in other seasons, however, have certain advantages.

WINTER: Photographs taken when the leaves are off the deciduous trees are favored in parts of Canada where the softwoods are the only commercially important species. There is usually more good flying weather in this season; the absence of hardwood foliage simplifies the recognition of softwood, mixedwood, and hardwood types; and a light cover of snow provides a valuable contrast in measuring the heights and densities of softwood stands, and for distinguishing the thin-crowned jack pine from the denser foliaged spruce and fir.[2]

Winter photography is preferable wherever the hardwood species are of no commercial value; but this situation rarely occurs in the eastern United States. Throughout this region winter photographs are inferior to photographs taken

[2] Seely, H. B. 1935. The use of air photographs for forestry purposes. *Forestry Chronicle* 11: 287–293.

at other seasons, because the necessary tree measurements can be made on photographs of hardwoods only when the trees are in leaf.

FALL AND SPRING: When the hardwood foliage is turning in the fall, and when it is coming out in the spring, many variations in tone between the major species are apparent, and many major types can be more easily differentiated. Although pictures taken in these seasons are theoretically the best,[3] they are difficult to get and difficult to use. It is almost impossible to photograph extensive areas at just the right stage of coloring. There are seldom more than six or eight days suitable for aerial photography in any one fall or spring month, and but few of these days coincide with the time of best coloring. On two occasions, once in the fall and once in the spring, a plane was held ready to photograph the Harvard Forest at the height of the seasonal coloring. In both cases, the weather did not clear until the stage of differential coloring had passed, and the project was unsuccessful. If the flight strips over a large area run north and south, the stage of coloring at the north end of the area is frequently entirely different from that at the south end. Likewise, the stage of coloring will vary widely over a thousand foot difference in elevation. Under such conditions, the observer must be thoroughly familiar with the locality to avoid serious errors in type mapping.

Generally speaking, fall or spring photography is unreliable and unsatisfactory except when a relatively small area can be photographed under ideal conditions. In this case, fall photography is preferable to any other.

SUMMER: If both hardwood and softwood species are to be measured, mapped according to age or condition class, and their volumes estimated on aerial photographs, photographs should be taken during the period when the trees are in full leaf. Practically all forest areas in the eastern and southern United States should be photographed during this season.

Films and Filters

In the various experimental flights, panchromatic, infrared, and two types of color film were used. The first two types were used with various filters.

PANCHROMATIC FILM: In all tests Kodak Super XX panchromatic film was used with a haze penetrating filter. This standard material produced excellent photographs in all cases. Tree heights and other detail could be measured with ease. The major forest types, however, were not always easy to differentiate.

Generally speaking, tone is not a reliable factor in classifying timber species on panchromatic film. Although occasional stands may photograph darker or lighter than surrounding timber, the relative tones are apt to be variable.

The experienced forester can often distinguish the major forest types on panchromatic aerial photographs; but he will not rely solely upon tone, but rather on a combination of tone, texture, shadow, and shape of crown.[4]

In the northern forest, the conical shape of the spruce and balsam is in marked contrast to the globular shape of the hardwood crowns. The small even crowns of the aspen and paper birch are easily distinguishable from the large, uneven crowns of the sugar maple, beech, and yellow birch. A key to the recognition of the northern forest species is given by Losee.[5] On photographs with a scale of 1:20,000 or larger, softwood, mixedwood, and hardwood types can gen-

[3] Standish, Myles. 1945. The use of aerial photographs in forestry. *Journal of Forestry* 43: 252–257.

[4] Andrews, G. S. 1940. Notes on interpretation of vertical air photographs. *Forestry Chronicle* 16(3): 202–215.

[5] Losee, S. T. B. 1942. Air photographs and forest sites. *Forestry Chronicle* 18: 129–144; 169–181.

erally be recognized, but not the important jack pine and white pine types. In the Quebec tests (series D and E), where panchromatic film was used with both the Aero 1 and the No. 12 filters, no appreciable difference was found in the quality of the pictures and the tone of the forest trees.

In the forests of central New England, panchromatic photographs taken in summer are of limited value for timber type mapping because of the complexity of the forests and the lack of great differentiation in crown shape and stand texture.

In the southern forest, panchromatic photographs are of value in distinguishing forest types only where the major types are strikingly different in appearance. For instance, the open pine flatwoods are easily separated from the southern cypress-gum swamps, but the different pine types cannot be easily delineated.

INFRARED FILM: In all tests Kodak type B infrared film was used. It was exposed in conjunction with three filters: 89A (dark red), 25 (light red), and 12 (minus blue). All combinations gave better results than other kinds of film as far as tone differentiation of species was concerned. Tone contrasts were most marked in the 89A series, but not sufficiently to permit distinguishing any species that could not be recognized on photographs taken with the 25 and 12 filters. Resolution of detail differed noticeably, but was poorest on the 89A photographs and best with the No. 12.

In the northern forest, the characteristic tones of the principal species were:

Very dark: black spruce, red spruce
Dark: gray balsam fir, jack pine, red pine
Medium gray: white pine, white spruce
Light gray: tamarack
Very light: paper birch, yellow birch, aspen, sugar maple

Although balsam fir photographs lighter than black spruce, the two species occur in mixture in many cases and blend together. In fact, all the trees which characteristically occur in mixtures cannot be readily recognized except on relatively large scale photographs. In this category are red pine, white pine, white spruce, and tamarack. In the Quebec tests, white pine had much the same tone as the hardwoods in the infrared flights, and red pine was lighter than on other infrared tests, possibly because the photographs were underexposed. In the same series yellow birch was darker in tone than aspen.

The advantages of infrared film over panchromatic are shown in Figures 1 and 2. These pictures were taken on the same day over central Quebec in August 1945. On the infrared photograph, the dark forested areas are black spruce; the light colored areas, paper birch and other hardwoods; and the speckled areas, a mixture of spruce and hardwoods.

In central New England the tones of the predominant species on infrared photographs were as follows:

Very dark: red pine, red spruce, Scotch pine, ponderosa pine
Gray: white pine, white spruce, Norway spruce
Light gray: hemlock, European larch, tamarack
Very light: red maple, sugar maple, red oak, white oak, paper birch, gray birch, and other hardwoods

All the important forest types of this region could be distinguished on infrared photographs, with the exception of the various subdivisions of the hardwood forest, which had to be delineated on the ground.

The variations in tone of the principal timber species of the coastal forests of North Carolina were:

Very dark: loblolly pine, southern white cedar, red cedar

FIG. 1. Akos Lake, Quebec. Panchromatic film with No. 12 filter. 1:18,000. August 23, 1945. Photo by Royal Canadian Air Force.

Gray: southern cypress
Very light: black gum, red gum, yellowpoplar, and other hardwoods

The forest types of this area may all be distinguished on infrared film by the experienced forester. The cedars have characteristically conical crowns which are in marked contrast to the rounded crowns of the loblolly pine. All three species typically occupy widely different sites. The hardwoods need only be broken down into swamp hardwoods and upland hardwoods on the basis of topography. Southern cypress is slightly darker in tone than the swamp hardwoods with which it occurs in mixture, and may be identified by careful observation.

The test series flown in southern Alabama revealed the following tone differentiation on infrared film:

Very dark: loblolly pine

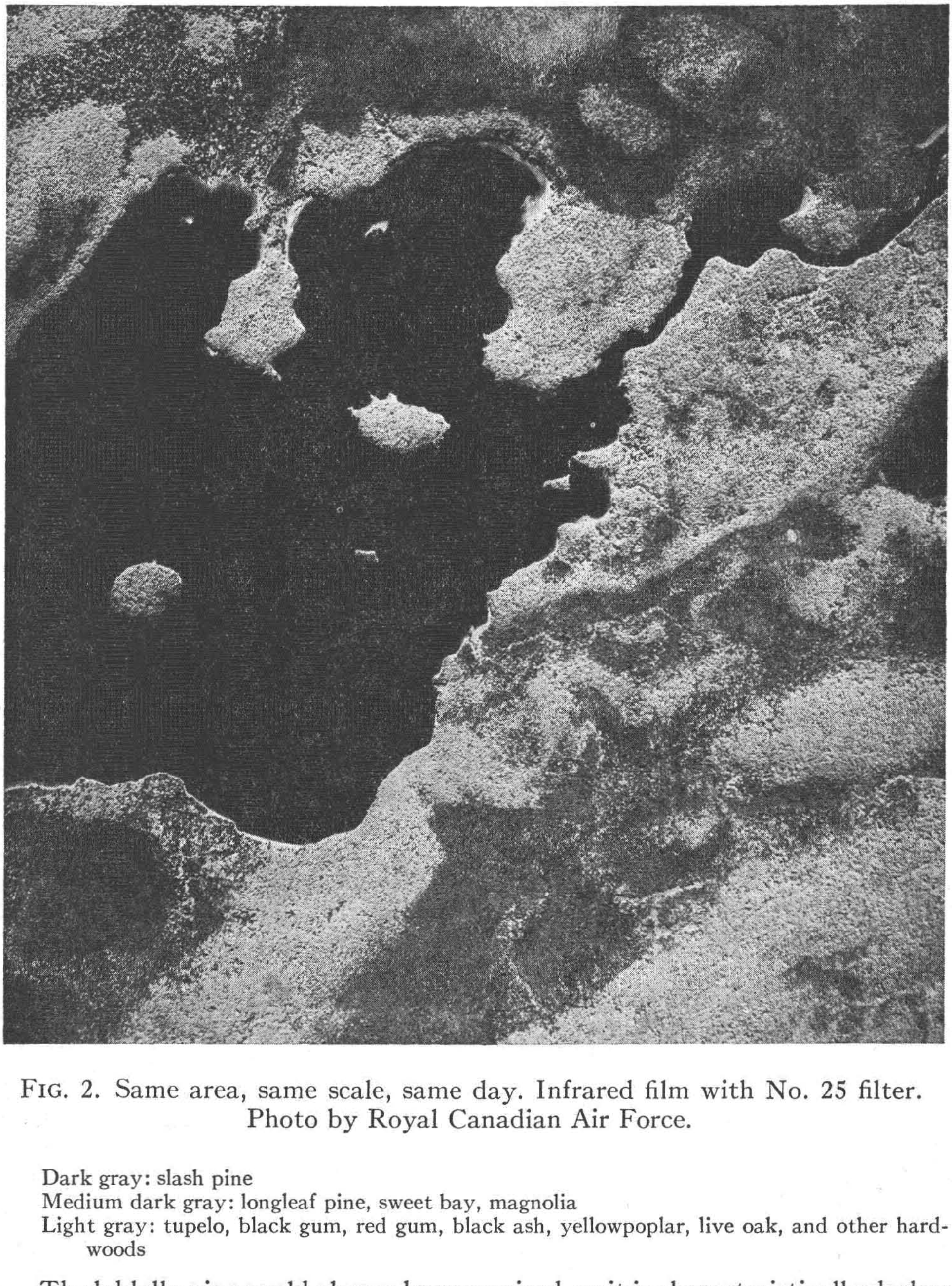

FIG. 2. Same area, same scale, same day. Infrared film with No. 25 filter. Photo by Royal Canadian Air Force.

Dark gray: slash pine
Medium dark gray: longleaf pine, sweet bay, magnolia
Light gray: tupelo, black gum, red gum, black ash, yellowpoplar, live oak, and other hardwoods

The loblolly pine could always be recognized, as it is characteristically darker than the other southern pines. Although slash pine was generally darker than longleaf pine, the two were not always distinguishable on the basis of tone alone. However, slash pine characteristically grows with bottomland hardwoods on the wettest sites, and occurs in pure stands on the moist borders of the bottoms and gum swamps. Longleaf, on the other hand, is almost entirely confined to the higher and better drained localities, where it occurs either in pure stands or in mixture with upland hardwoods. Also, the crowns of the slash pine are finer textured than those of longleaf and are apt to present a smoother appearance on aerial photographs. On the combination of these three characteristics—difference in tone, habitat, and texture—the two species could be separated in most cases.

At the time the Alabama photographs were taken (mid-October), the southern red oak and the other upland deciduous oaks had yellowed foliage, and had, apparently, lost some of their leaves, exposing the litter beneath. Consequently, these upland oak types had a characteristically dark tone which rendered recognition easy.

The older the tree, the darker it appears on infrared photographs. The reason for this is not wholly apparent, as the foliage does not differ widely between specimens of the same species at different ages. However, as the more irregular crowns of older stands absorb more infrared light than the relatively smooth crowns of younger stands, they would normally photograph darker. In any event, the range of tone in any one species is wide. For instance, very young white pine is sometimes so light in color that it cannot be easily distinguished from hardwoods; old white pine photographs nearly as dark as red pine. The variations in tone described above for four forest regions hold for trees of any one age, but care must be exercised in distinguishing between old trees of one species and young trees of another.

The angle of elevation of the sun affects the tone of foliage on infrared photographs by influencing the amount of reflection. Hardwoods on a south slope which faces the sun appear lighter than the same species on a north slope which faces away from the sun. The variation in tone is not great and does not appear to affect the accuracy of type mapping work. A series of oblique photographs at Petersham (Series B, units 7 and 8) taken into the sun, away from the sun, and at right angles to the sun, did not reveal any significant differences in tone or resolution.

COLOR FILM: None of the color film exposed gave as good differentiation of forest species as did infrared. When properly exposed, however, it is superior to panchromatic film in this regard. In all the tests, much of the color photography was of inferior quality owing to the difficulty of guessing the correct exposure and to the large amount of blue which registers when photography is done at more than a few thousand feet. The series B and C color pictures were very poor, although the low altitude at which the series B pictures were taken made much detail distinguishable. The series D color pictures were a complete failure, and only series G gave results comparable to black and white photography. Apparently neither Kodachrome nor Aero Kodacolor film at the present stage of their development produce sufficiently good detail or tone differentiation to justify the cost of color photography for forestry puropses. Indeed, it is doubtful whether any normal color photography will prove superior to infrared film for forestry work, because the visible differences in tone between forest trees is much less than the differences in reflectance of infrared light from the different types of foliage.

Scales

The aerial photographer and the forester talk of scales in different terms. The former prefers to use the natural scale, the representative fraction, while the latter speaks in terms of feet per inch or chains per inch. Thus, an RF of 1:15,840 is equivalent to 1,320 feet per inch, 20 chains per inch, or 4 inches to the mile. In the following discussion, the natural scales are used.

The scales of photographs now being used for forestry purposes differ widely. In the United States, much photography has been done at the standardized U. S. Department of Agriculture scale of 1:20,000. Relatively few forest areas have been photographed at a larger scale, while the U. S. Forest Service has had to use some photographs taken at 1:30,000 and smaller in its Forest Reappraisal Project. Canadian usage favors photographs scaled at 1:15,840 (four inches to the mile) for regional forest survey work, and 1:9,600 for areas being carefully cruised and logged.

In the present tests, photographs were taken at scales varying from 1:3,000 to 1:23,000. Scales of 1:6,000 or larger were patently unsatisfactory, because of the small area covered by each photograph, the high cost of photography, and the great distortion caused by even moderate topographic relief. With the largest scale pictures taken, it was difficult to resolve the images stereoscopically.

The optimum scale for forest aerial photography depends upon the purpose of the survey and the character of the forest. The scale should be the smallest and, consequently, the least expensive that will give the desired results. However, the higher cost of large scale photography is often more than justified by the greatly increased usefulness of the photographs. Photographs taken at a scale smaller than 1:20,000 in central New England are difficult to work with for forestry purposes. In this region the forest stands are very small, irregular, and highly complex, as are the farms, towns, and cities, and the patterns of land ownership. Even for regional surveys, photographs at 1:15,840 are needed, while larger scale photographs should be taken for more intensive work (Table 2).

TABLE 2. OPTIMUM SCALES FOR FOREST AERIAL PHOTOGRAPHY

Purpose of photography	White pine-hardwood region	Spruce-fir region	Southern pine region
Regional survey General type mapping	1:15,840	1:20,000	1:24,000
Local survey Standard type mapping General volume estimating	1:12,000	1:15,840	1:20,000
Intensive management and Volume estimating	1: 9,600	1:12,000	1:15,840

In the spruce-fir region of northeastern United States and Canada, the terrain is relatively level, and the forests and forest ownerships extend unbroken over large areas. Under these conditions, photographs can and should be taken at smaller scales than in the white pine-hardwood region (Table 2). Although relatively few timber species are present in this region, they occur in a variety of mixtures over small areas, so that there are few extensive areas of any one forest type.

In the southern pine region, conditions are ideal for aerial photography. The topography is generally flat, and the extensive pine forests are open-grown, so that the aerial observer may readily see through the foliage to the ground. While some of the major forest types do not vary widely in their visual characteristics, their ecological habits make them readily distinguishable. Photography may successfully be carried out at smaller scales than farther north.

The suggested scales are not hard and fast, but rather good standard scales for each particular purpose in the region studied. For any specified job, the scale might vary considerably from those suggested, depending upon the local problem and the amount of money available.

Discussion

PHOTOGRAPHIC MEASUREMENTS: Aerial timber cruising, one of the primary uses which the forester will make of aerial photographs, involves the measuring of trees and stands. Five different measurements can be made on photographs: (1) heights, either of individual trees or stands; (2) crown diameters; (3) number of trees per unit of area; (4) per cent of area occupied by tree crowns; (5) areas.

The first three of these items involve accurate quantitative analysis of detail, and are, consequently, best made on photographs on which the detail is clearly resolved. The resolution of detail is best on panchromatic film and next best on infrared film exposed with the minus blue (12) filter. In photographs taken with infrared film and either the 25 or 89A filter, there is a loss of resolution sufficient to influence the accuracy of tree measurements. This loss is due to the distance the plane travels during the longer exposure of the film with these filters.

Forest areas can be measured equally well on all types of photographs, provided that the forest boundaries can be seen. Stand and type boundaries are generally clearest on infrared photographs, and hence their area can be measured with the greatest precision.

The accuracy of estimates of the percent of a given area covered by tree crowns is dependent upon the ability of the observer to see holes in the crown canopy, rather than upon the observation of individual tree detail. The ease with which this can be done depends upon the type of ground cover, and is possibly a little easier on panchromatic film. Shadows are less dense on panchromatic pictures, making small openings more easily discernible.

The statements above are corroborated by tests conducted at the Harvard Forest. In these tests, trees and stands were first measured on aerial photographs and then checked in the field. Measurements sufficiently accurate for many forestry purposes were obtained on photographs with scales ranging from 1:10,000 to 1:18,000. At these scales trees can be classified in the majority of cases into 10-foot height classes, and tree crowns into 3-foot diameter classes. Crown closures can be estimated to the nearest 10 percent, and stand boundaries can be clearly seen.

There are some mechanical defects inherent in all aerial photography which require more or less ground control, depending upon the nature of the particular problem. Variations in tilt and altitude of the plane caused as much as ten percent error in area determinations in the experimental photographs at the Harvard Forest. Such distortions will effect any measurements involving linear distances on the photograph, although they may be compensating when measurements are made over a series of pictures. When area detail is compiled onto a map, the scale of the photograph is adjusted to that of the map, and little error will be introduced.

INSECT AND DISEASE DAMAGE: Stands of defoliated and dying trees commonly appear black on infrared photographs, white on panchromatic photographs, and in natural color on color photographs. In all cases the color effect is caused by the browning of the injured foliage, or by the visibility of the forest floor beneath the stand as a result of defoliation. Large areas defoliated by the gypsy moth in Massachusetts in 1944 were clearly discernible on the panchromatic, infrared, and color photographs.

Another destructive insect is the spruce budworm, which periodically causes severe damage to the fir and spruce of the northern forest. Stands infested with the spruce budworm appear reddish from the air when the injury is light; they become yellowish, grayish yellow, and finally steel gray as the infestation progresses toward complete defoliation. These different tones can be distinguished on various types of color photographs, and probably on infrared photographs. In the Quebec experimental flights, an attempt to distinguish spruce and fir stands sprayed with DDT from others badly infested was unsuccessful, because the flying was delayed until the trees had largely recovered.

SEPARATION OF HARDWOOD SPECIES: Most hardwoods cannot be distinguished from one another, even on infrared film. There is little likelihood that this can ever be done with small scale photographs. Experiments have shown that the foliage of all species of green plants reacts similarly in every band of the visible and infrared spectra. Variations in tone on the photographs result not from qualitative variations between species, but rather from quantitative differences in the wave lengths of light to which the film is sensitive. Since conifers absorb more infrared light than hardwoods, they photograph darker on infrared film, even though the reflectance spectrum pattern is similar for the two groups of species. The variation in tone between the different conifers photographed on infrared film is largely due to differences in leaf structure, leaf shape, and leaf arrangement, which cause some species to absorb more infrared light than others, and consequently, to photograph darker. Such differences in structure, however, are not marked among hardwoods. This lack of variation, coupled with but small differences in reflectance between the various hardwood species, makes unreliable the classification of most hardwood species on the basis of the tone in which they photograph. On the other hand, as detailed earlier, local conditions make it possible to distinguish yellow from white birch in the Quebec flights, upland oak from other upland hardwoods in Alabama, and sweet bay from black gum in the same area.

Summary

For most forestry purposes, as well as for other land use purposes, the best combination of photographic materials is that of infrared film with a light colored filter. This combination produces pictures with well resolved detail and with marked differentiation in tone between the major timber species. The minus blue filter (No. 12) has proved very satisfactory in this connection, but a somewhat darker filter may turn out to be preferable.

The choice of scale depends largely upon the use to which the photographs are to be put. Photographs at 1:15,840 (four inches to the mile) are almost universally applicable to forestry work. With them timber types can be carefully studied and individual trees measured. Practical scales may vary from 1:10,000 to 1:24,000.

Forest species cannot be positively identified and measured unless the photo-interpreter is familiar with the area being studied and has the opportunity of checking himself on the ground. Intensive study on the ground is very helpful in the interpretation of any area, and a knowledge of the ecological habits of the species present will enable differentiations to be made which are not otherwise apparent.

The results obtained from the experimental photography discussed in this paper indicate that the usefulness of aerial photographs to the forester can be greatly increased by the choice of the proper specifications without greatly increasing the cost of the photographs or decreasing the usefulness of the photographs in other fields. While the present work suggests what these specifications should be, much experimentation is needed to evaluate more fully the relative merits of various films, filters, focal lengths, and other variables in aerial photography.