

Recognition of Tree Species on Air Photographs by Crown Characteristics^{1,2}

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ABSTRACT: *The characteristics of tree form important in species recognition on air photographs are discussed, and brief references made to the value of phenology and ecology in species identification. Descriptions are given of the appearance of over 20 tree species on air photographs, along with elimination keys for the identification of these species.*

INTRODUCTION

TREE species are identified on air photographs through a process of elimination. The *first step* is to eliminate those species whose presence in an area is impossible or highly improbable because of location, physiography or climate. The *second step* is, through a knowledge of the common species associations and of their requirements, to establish which groups of species occurs in the area examined. The identification of individual tree species in this group, using crown characteristics, usually is the *final stage* of this process. For the first two steps a thorough background knowledge of the forest is required; even then many weak clues, none of which would be sufficient if used singly, must be used.

The value of field experience and other studies of the forest is readily apparent. But the intensive local knowledge desirable is often not available. Also such secondary characteristics as topography, drainage and aspect are not always reliable indicators of the presence of certain tree species. These disadvantages would not apply if one could use inherent species characteristics such as crown-shape, type of trunk, branching habit, and the characteristics of the foliage as key features. While it is not possible to identify trees solely by such morphological characteristics—at least not at small and medium

scales—the further one can advance the knowledge of how to identify species by the appearance of the trees themselves, the closer one will be to an objective method of species identification on air photographs.

It is therefore the purpose of this paper to deal mainly with the characteristics of the tree form, such as crown-shape and branching habit. For each tree species a detailed description of its appearance on air photographs is given, and the more important distinguishing characteristics are combined in elimination keys. In some cases it is possible to identify a species using a key alone, but usually some reference to the individual tree descriptions is necessary. In a few instances references to the ecological and site requirements of different species are made, where they are a common aid in interpretation. For species confined to British Columbia, not dealt with in this paper, reference may be made to the British Columbia Forest Survey Manual (3).

This study of the appearance of tree species on air photographs is not confined to small and medium scales of photography which are commonly used but, because of the recent interest in sampling photographs at very large scales, these are also considered. Unless otherwise stated, all photographs used as illustrations are panchromatic and all references to photographic tone apply to these only.

¹ A more comprehensive version of this paper was published as Technical Note 95 by the Department of Forestry, Ottawa.

² The author wishes to acknowledge the assistance and advice given by Mr. J. M. Robinson and others of the Department of Forestry who did earlier work on this project. Most of the air photographs used in this paper were obtained from the collection of the Forest Inventories Section.

GENERAL CONSIDERATIONS IN THE RECOGNITION OF THREE SPECIES

SCALE OF PHOTOGRAPHY

The extent to which species can be recognized on air photographs is largely determined by the scale, as well as by the method and quality of photography.

The value of the characteristics of tree form, such as crown-shape and branching habit, which are used for identification on large-scale photographs, becomes progressively less as the scale is decreased, until eventually these features become so indistinct that they are replaced by photographic tone, texture and shadow pattern, as the key characteristics. These in turn are dependent upon too many variables to make possible specific rules of interpretation. Some of these variables are altitude of the sun, length of exposure, method of printing and developing, atmospheric haze, and all the details of camera and lens construction. Differences in the tone of species are often very useful but a key based on tone has the limitation that it can be used only for the particular series of photographs from which it was constructed. Species identification on small-scale photographs is more of an art than a science, and the success will, to a high degree, depend upon the interpreter's background knowledge of the area photographed, and on his skill in evaluating the combination of factors which determine the final photograph.

The detail which can be seen at different scales varies with the quality and method of photography and with the nature of the forest photographed, but the following may serve as a rough guide. On photographs at very large scales, such as $1''=50'$, most species, except a few with very similar characteristics, can be recognized almost entirely by their morphological characteristics. The twig structure and leaf arrangement and shape are important clues to species recognition, as for instance when the individual leaves of ash and butternut become visible. As a result one can usually draw up objective descriptions of the distinguishing characteristics of each tree species.

At scales of $1''=200'$ or $250'$, small and medium branches are still visible, and individual crowns can be clearly distinguished, but these scales are no longer suitable for exact species identification. At $1''=660'$ individual trees can still be separated, except when growing in dense stands, but it is not always possible to describe crown-shape. At $1''=1,320'$ crown-shape can still be seen by

tree shadow, for trees growing in the open, or for very large trees. At smaller scales individual trees generally cannot be recognized when growing in stands, and stand-tone and texture become the important means of identifying forest types, while crown-shape is of little value. There are, however, exceptions: on exceptionally sharp photographs at a scale of $1''=3,200'$, the narrow pointed crowns of big northern white spruce trees could clearly be seen.

IDENTIFICATION BY CROWN CHARACTERISTICS

On vertical air photographs, trees are seen in an unusual perspective, so that many key characteristics by which trees are ordinarily identified are no longer visible. Several new ones appear. For instance the trunk may be hidden by the crown, but the branching habit in the upper parts of the crown will show itself distinctly. In general it is easier to identify trees seen in sideview and accordingly species can be better recognized on obliques than on vertical photographs. However, on the verticals trees near the edges of the photograph are usually sufficiently displaced to be seen partly from the side. To use air photographs to the best advantage it is essential that trees be viewed stereoscopically. This is particularly applicable to vertical photographs, for it is most difficult to recognize even general crown-shape without stereoscopic examination. This paper contains stereograms illustrating individual species, which should be viewed through a stereoscope.

Although there is one, or in some cases several, typical crown-shapes for each species, there will be many deviations, for crown-shape is varied greatly due to the influences of environment. In this paper emphasis is placed on the description and identification of these typical crown forms. Some species are less variable than others, but in no case can rules regarding crown-shape be established, from which exceptions do not exist. A few species have typical crowns which can be easily described by definite terms such as oval, conical, or more rarely cylindrical. But often, especially in the case of the hardwoods, it is extremely difficult to describe crown-shape. Typical crowns for various species are shown in Figure 1; Figure 2 gives overhead views of some of these crowns.

The characteristics of the foliage influence the tone which crowns will show on a photograph. Trees which have large or glossy leaves, such as sugar maple and red oak, may appear lighter in tone than trees with small

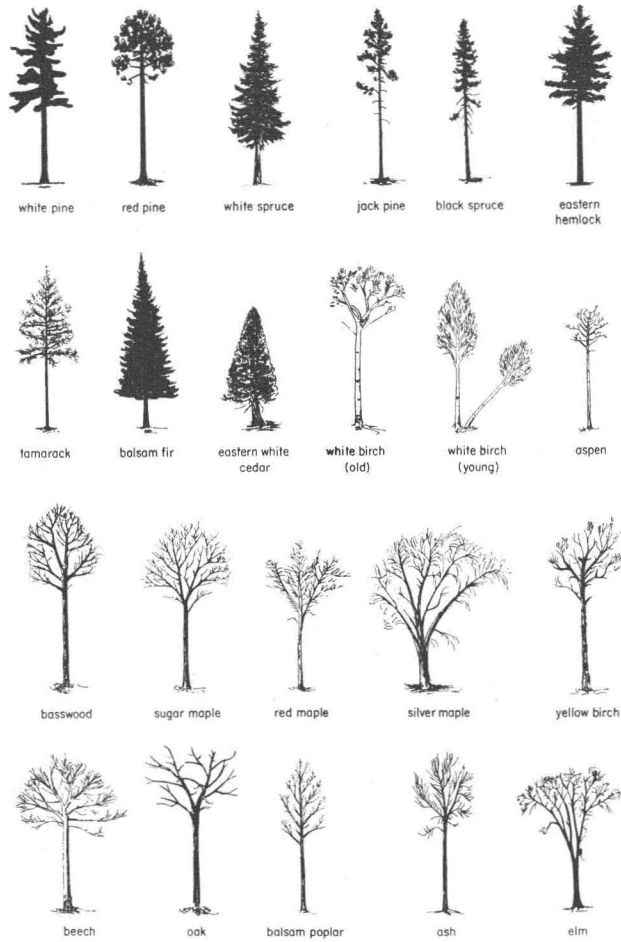


FIG. 1. Typical tree forms.

and dull leaves, such as elm. Trees with a dense network of small twigs at the ends of the branches, appear lighter on winter photographs than others.

Shadows visible inside the crown, as well as the shadow cast on the ground, are strong indications of certain features of the crown. Occasionally it is possible to see the entire shadow of a tree in an opening in the forest; in such cases more detail of crown-shape can often be seen from the shadow image than from the actual tree image.

At larger scales the density of the shadow cast is a useful identifying characteristic; a very dark shadow will indicate a compact crown and dense foliage, and a light shadow an open crown and thin foliage. For instance, against a background of snow both the crown and the shadow of spruce will be darker than that of jack pine. Similarly for trees with dense foliage, there will be a greater tone

contrast between the shaded and the sunny side, than for trees with little foliage. No large shadows visible inside a crown may

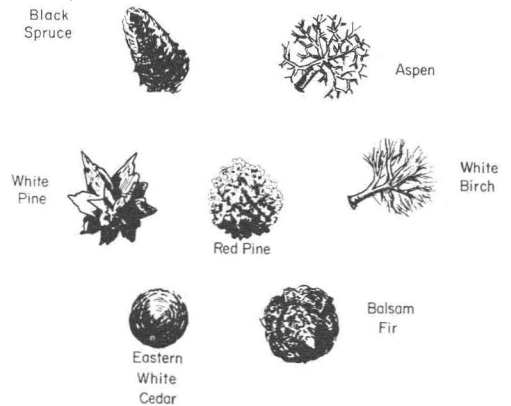


Fig. 2. Overhead view of some tree crowns.

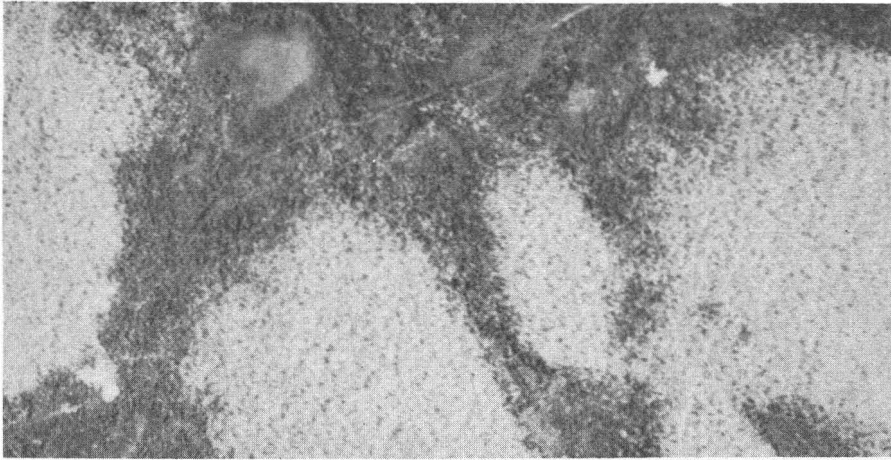


FIG. 3. Spring photograph showing the great difference between the light tone of hardwoods and the dark conifers. (Scale 1 inch = 1,320 feet.)

mean that the individual branches are not prominent or that the crown is closed. This feature is much less apparent at the small than at large scales.

In general conifers are more easily recognized than hardwoods, because most have a definite and characteristic shape; hardwoods tend to be more irregular. It is difficult to identify very young trees of any species because these often have not developed typical crown-shapes.

The northern tolerant hardwoods, that is the maples, beech, elm, and yellow birch, are the most difficult species to identify on air photographs. With the exception of sugar maple, they seldom form pure stands, but usually grow in complex mixtures, frequently with white pine, hemlock, white spruce or red pine. These stands are characteristically of uneven age and many different crown sizes can be observed. The tolerant hardwoods, as a group, are recognized by their large, dense and rounded or irregular crowns.

Unfortunately the identification of individual tree species in this group by crown-shape is seldom possible at medium and small scales, because the various species either do not possess a sufficiently distinct crown form, or they cannot develop it in a closed stand. In general they tend to develop a tall, straight trunk when growing in closed stands, while in the open they become more branchy and tend to have a deeper and more symmetrical crown. As a rule, overmature trees, whether growing in a forest or in the open, develop wide-spreading, open crowns. Since the size of crowns is determined by the inherent species characteristics and by site and

competition, there are no typical crown dimensions which can be relied upon for identification. Often the only difference which can be detected between species will be a slight difference in tone. The interpreter may therefore be able to establish that several species are present in a given area, but to identify them he will be forced to rely on his familiarity with species associations on the ground, or on his knowledge of the relationship of species distribution and physiography.

When one wishes to map the species composition on a given area using photographs, the following procedure is normal: first the photos are examined to determine which of their technical characteristics, such as tonal variations, are most useful for species identification. This would be considered in conjunction with any existing ground information; doubtful conditions would be noted. Then, if at all possible, the interpreter would go into the area with the photographs for spot-checking and develop a working key for that particular area; this would then be used for the detailed mapping of timber types.

THE VALUE OF PHENOLOGY IN SPECIES IDENTIFICATION³

The changes in the appearance of trees in the different seasons of the year sometimes makes possible identifying individual species or groups of species. The most obvious example is the separation of deciduous and evergreen trees which is so easily made on

³ The author has treated this subject in detail in "Phenological Aids to Species Identification on Air Photographs," Canada, Dept. of Forestry, Tech. Note 104.

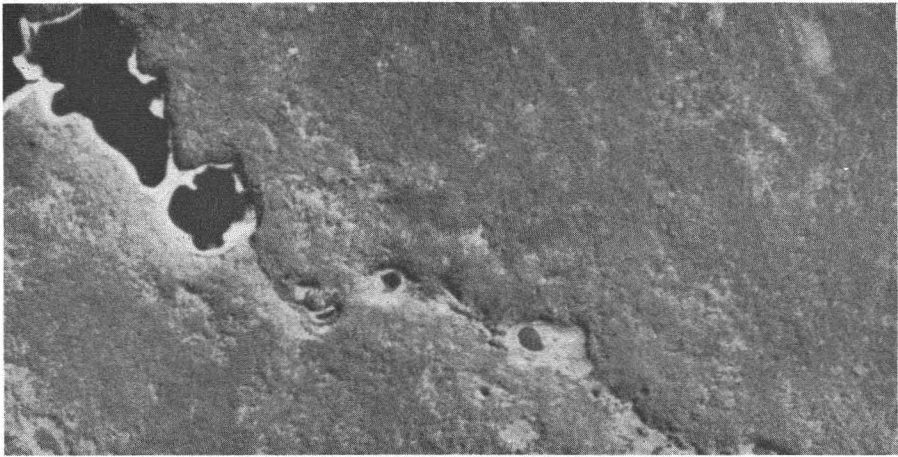


FIG. 4. Jack pine, white spruce and aspen stands in the late summer. There is little tone contrast between aspen and the conifers. (Scale 1 inch = 3,200 feet.)

photographs taken when the deciduous foliage has fallen (Figure 6). This distinction can also be made on spring photos taken shortly after the flushing of the leaves (Figure 3) or on fall photos taken after the trees have turned color (Figure 5). In both these cases hardwoods appear much lighter than softwoods and on the spring photographs the hardwood stands show a rough and uneven texture. On summer photographs differences in tone are small (Figure 4).

The order in which trees of different species leaf out may provide valuable clues to species recognition even though it is not absolutely reliable because it is influenced by site and the early spring temperatures, genetic variations within one species, and differences in the age and vigor of trees. While no signif-

icance should therefore be attached to small differences between corresponding dates for two species, large differences are reliable guides to their relative order of leafing. For example, trembling aspen and white birch consistently are among the first trees to leaf out, while the oaks, ashes and large-tooth aspen are among the last. These two groups could be distinguished on photographs taken shortly after trembling aspen and white birch have leafed out.

The rate at which leaves of different trees develop also determines their appearance in the first weeks after the leaf buds have burst. The leaves of the elms for instance grow very slowly and therefore these trees will appear as apparently bare or only partly in leaf for some time after leafing has begun;

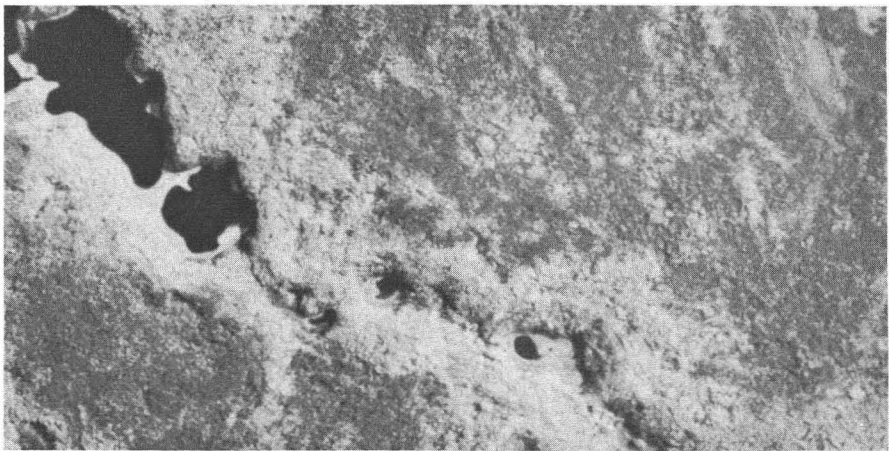


FIG. 5. Same area as in Figure 4, after fall coloring has set in. Aspen is light, the conifers dark. (Scale 1 inch = 3,200 feet.)

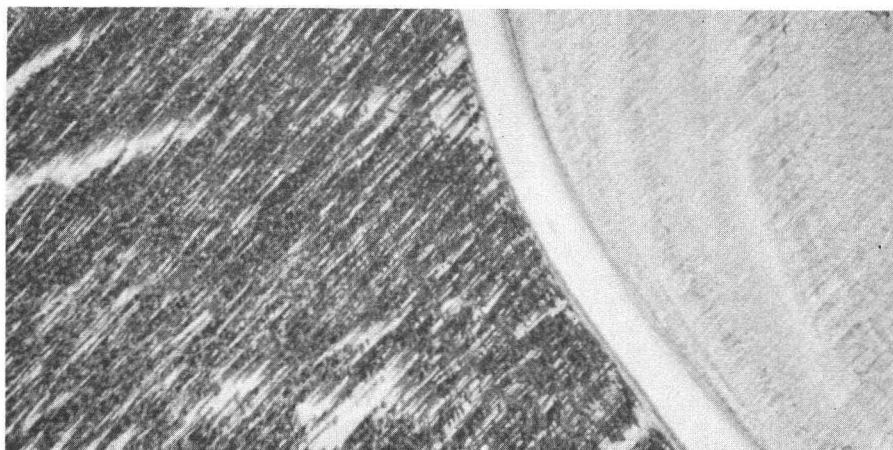


FIG. 6. Winter photograph of an evergreen stand (white spruce) at left, and a deciduous stand (balsam poplar) at right. (Scale 1 inch = 660 feet.)

this will make possible their identification when viewed with the more rapidly developing maples and basswoods.

The young foliage, the twigs and the flowers give some tree species a characteristic color in the spring. Examples are the russet twigs of white birch, the catkins of the poplars, and the red flowers of red maple. Most of these features would be useful for species recognition only on color photographs, but several can be seen on panchromatic pictures. A striking example of this kind of species distinction was observed on panchromatic photographs taken a few days after large-tooth aspen had leafed out. In this case, the young leaves, which are covered with fine white hairs, made the crowns appear lighter than those of all other hardwoods. Losee (9) suggests that the yellow color, which jack pine shows during flowering may be brought out by suitable filters. If feasible then the sometimes difficult distinction of spruce and jack pine could be made.

Tone differences between hardwoods, which are small during the summer, become definite during the fall, as some species turn yellow, and others red or brown. Losee (8) mentions some of the individual hardwood species which are recognized on fall photographs by tone differences. White birch and aspen showed the lightest tones, then followed sugar maple, beech, and yellow birch and last red oak, which appeared darkest. The fact that different species turn color at different times can also be used as a basis for distinction. In one case the poplars were successfully separated from the maples and basswood, which were in their fall colors.

As a general rule the order in which trees of

different species lose their leaves is an unreliable guide to their identification, because variations within individual species are too great. However, in a few cases the order of leaf fall may have practical significance, for instance the ashes, hickories and walnuts lose their leaves well ahead of most other hardwoods and beech and oak are among the last to be defoliated. However, the best species distinctions in the fall can probably be obtained on air photographs taken when fall coloring is at its peak, instead of when some trees have lost their leaves.

THE ROLE OF ECOLOGY IN SPECIES IDENTIFICATION

A knowledge of the ecological and silvicultural characteristics of species is of great value in recognizing tree species on air photographs. But identification of a species on this basis alone is not positive, for no species has such rigid site requirements that exceptions do not occur; some, for example white pine, will grow over a great range of sites. Yet many species are characteristic of a certain habitat, and in practice physiography and other features of the area examined are very important keys to the species found in the area. For instance, if hardwoods are observed on a swampy location, they are more likely to be elm or black ash than beech or oak; similarly black spruce can often be recognized because of its tendency to grow in bogs, while white spruce is found more often on better drained soils. A shallow layer of soil, which may be indicated by frequent outcrops of bedrock, would exclude trees which have a deep root system.

Familiarity with the common species assoc-

KEY TO THE CONIFERS

- 1. Crowns small, or if large then definitely cone-shaped.
 - Crowns broadly conical, usually rounded tip, branches not prominent.....cedar.
 - Crowns narrow, often cylindrical, trees frequently grow in swamps.....swamp type black spruce.
 - Crowns conical, deciduous, very light-toned in fall, usually associated with black spruce.....tamarack.
 - Crowns narrowly conical, very symmetrical, top pointed, branches less prominent than in white spruce.....balsam fir.
 - Crowns narrowly conical, top often appears obtuse on photograph (except northern white spruce), branches more prominent than in balsam fir.....white spruce, black spruce (except swamp type).
 - Crowns irregular, sometimes with pointed top, has thinner foliage and smoother texture than spruce and balsam fir.....jack pine.
- 1. Crowns large and spreading, not narrowly conical, top often not well defined.
 - 2. Crowns very dense, irregular, or broadly conical.
 - 3. Individual branches very prominent, crown usually irregular.....white pine.
 - 3. Individual branches rarely, very prominent, crown usually conical ..eastern hemlock.
 - 2. Crowns open, oval (circular in plan view).....red pine.

ciations found in the forest will often be useful; for example in cases where a species which is difficult to identify is commonly associated with one which is easily recognized. Therefore if the one species is recognized in a stand, the presence of the other can be expected. Conversely the presence of one species may make the presence of another most unlikely, for some species rarely occur together.

The type of stand which species tend to form can also be an identifying characteristic. Some species, for example basswood and white ash, never form pure stands, while others (e.g. aspen, jack pine) frequently occur in pure stands. If intolerant trees, such as larch and aspen, grow in mixed stands they usually will be dominants. The tolerant hardwoods often develop uneven-aged stands, and can therefore be recognized by the many different crown sizes. Other species, such as jack pine, aspen and white birch, which frequently come in after forest fires, generally form even-aged stands.

The property of aspen to produce root

suckers and to form clones may identify this species. Other species such as white birch and basswood sometimes coppice, with the result that eventually there will be several stems growing in a cluster.

WHITE PINE (*Pinus strobus*)

FIGURES 7 AND 8. This species usually has a straight and undivided trunk and a large crown of horizontal or ascending branches. The upper branches sweep upwards in a pronounced curve resulting in a bowl-shaped structure. The larger branches are very prominent, giving the crown an irregular, star-shaped outline when seen from above. This is the most useful distinguishing characteristic. Young trees often have a nearly conical crown, although less conical than that of most other conifers.

White pine is sometimes difficult to distinguish from over-mature eastern hemlock, which may develop a ragged and star-shaped crown, but usually hemlock has a more conical crown. Because of its dark green foliage, white pine usually appears dark on air photographs, but this cannot be relied on; individuals frequently tower above the other trees in the forest with the result that they will be more fully illuminated and therefore brighter than other species.

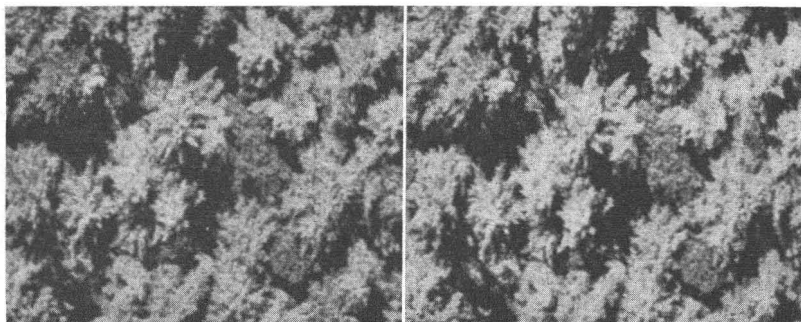


FIG. 7. Stereogram showing the star-shaped outline of white pine crowns. (Scale 1 inch = 50 feet, summer photograph.)

KEY TO THE HARDWOODS IN SUMMER

- 1. Crowns compact, dense, large.
 - 2. Crowns very symmetrical and very smooth, oblong or oval, trees form small portion of stand..... basswood.
 - 2. Crowns irregularly rounded (sometimes symmetrical), or billowy, or tufted.
 - 3. Surface of crown not smooth, but billowy..... oak.
 - 3. Crowns rounded, sometimes symmetrical, smooth-surfaced..... sugar maple,* beech.*
 - 3. Crowns irregularly rounded or tufted..... yellow birch.*

* (A local tone-key is usually necessary to distinguish these species.)

- 1. Crowns small, or if large, open or multiple.
 - 6. Crowns small, or, if large, open and irregular, revealing light-colored trunk.
 - 7. Trunk chalk-white, often forked, trees tend to grow in clumps..... white birch.
 - 7. Trunk light, but not white, undivided trunk reaching high into crown, generally not in clumps..... aspen.
 - 6. Crowns medium sized or large, trunk dark.
 - 8. Crown tufted, or narrow and pointed.
 - 9. Trunk often divided, crown tufted..... red maple.
 - 9. Undivided trunk, crown narrow,..... balsam poplar.
 - 8. Crowns flat-topped or rounded.
 - 10. Crowns medium sized, rounded, undivided trunk, branches ascending..... ash.
 - 10. Crown large, wide, trunk divided into big spreading branches.
 - 11. Top of crown appears pitted..... elm.
 - 11. Top of crown closed..... silver maple.

KEY TO THE HARDWOODS ON LARGE-SCALE WINTER PHOTOGRAPHS

- 1. Single, gradually tapering trunk reaching high into the crown.
 - 2. Branches ascending at sharp angle to trunk, trunk dark, crown narrow, twigs dark.... balsam poplar.
 - 2. Branches lateral, trunk light colored, crown rounded, twigs light..... aspen.

- 1. Trunk ends soon after limbing begins, does not reach high into crown.
 - 3. Main branches approximately at right angles to trunk.
 - 4. Branches bulky, coarse and twisted, trunk dark..... oak.*

* (Bark of red oak darker than for bur and white oak, branches of bur oak more twisted than red and white oak.)

- 4. Branches slender, very dense twig growth, trunk light-toned..... beech.
- 3. Main branches form acute angle with trunk.
 - 5. Wide-spreading crown formed by long, main limbs or secondary stems, small branches may droop.
 - 6. Dense twig growth on top of crown, smaller branches light-toned... silver maple.
 - 6. Top of crown with openings, branches dark..... elm.
 - 5. Usually only single trunk, crown not wide-spreading.
 - 7. Trunk and bigger branches chalk-white..... white birch.
 - 7. Trunk and bigger branches not chalk-white.
 - 8. Branches long and slender.
 - 9. Twigs fine.
 - 10. Usually small tree, tendency to grow in clumps..... red maple.
 - 10. Large tree when mature, usually not in clumps..... sugar maple, yellow birch.*

* (Main branches of yellow birch usually coarser than in maple, opposite branching of maple and alternate branching of yellow birch may be distinguishing feature.)

- 9. Twigs coarse..... ash.
- 8. Stout, rapidly tapering branches..... basswood.

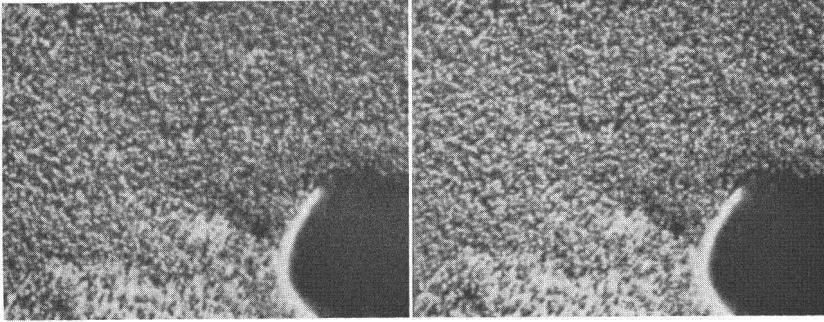


FIG. 8. An almost pure stand of white pine. Trees are tall, individual branches prominent, tree shadows on the ground show the characteristic shelflike branching of white pine. (Scale 1 inch = 660 feet, summer photograph.)

RED PINE (*Pinus resinosa*)

Figures 9 and 10. Red pine has a straight and undivided trunk which is usually clear of branches for at least one-half its height. Its crown is oval, not very dense and consists of stout, whorled, spreading branches. The tufts of foliage at the ends of the upturned branchlets give the tree a distinctive appearance. In the overhead view it is characterized by the circular outline of its crown, beyond which individual branches rarely protrude, as they usually do in white pine. Because the foliage is not as dense as that of white pine, the contrast between the illuminated and the shaded parts of the crown is less pronounced, and in some cases the trunk will show through the crown.

JACK PINE (*Pinus banksiana*)

Figures 11 and 12. In closed stands jack pine forms a small, narrow, open crown of many short and twisted branches, which are restricted to the

upper portion of the tree. In the open, crown shape is very variable, with the general tendency toward a more rounded but irregular form.

Jack pine is not difficult to distinguish from red pine with its almost spherical regular crown, or white pine with its wide and star-shaped crown, but it is sometimes difficult to separate from spruce. For pure stands this separation is not difficult, because jack pine stands usually appear hazy and show a very smooth and even texture, and this contrasts with the more ragged appearance of spruce. When growing in mixture with spruce the smooth appearance of individual jack pine crowns sometimes makes identification possible. In some cases the two species can be distinguished by the fact that spruce casts a denser shadow than jack pine. The thin foliage causes jack pine to appear in relatively light tones on winter photographs. On panchromatic film jack pine may be so light in tone that it will be confused with aspen, for both species often grow in pure and even-aged stands.

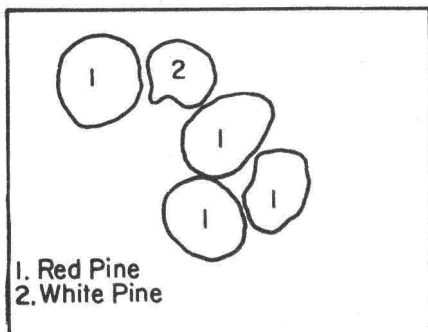
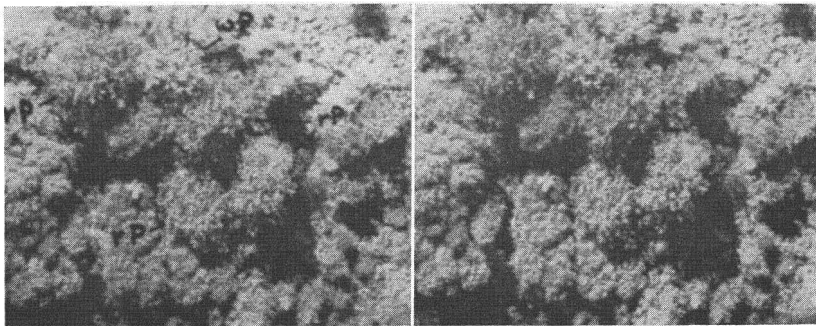


FIG. 9. Red pine at large scale. The crown is round and open. The tufts of foliage at the branch ends are characteristic. (Scale 1 inch = 50 feet, summer photograph.)



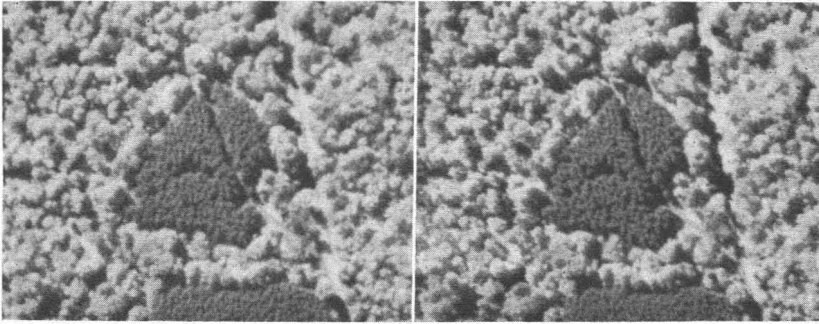


FIG. 10. Infrared photograph of a red pine plantation surrounded by a stand of basswood, sugar maple white birch and elm. Red pine has not yet developed its characteristic crown shape, but the crowns are more open and regular than white pine and not sufficiently pointed to be jack pine, spruce or balsam. (Scale 1 inch = 330 feet, summer photograph.)

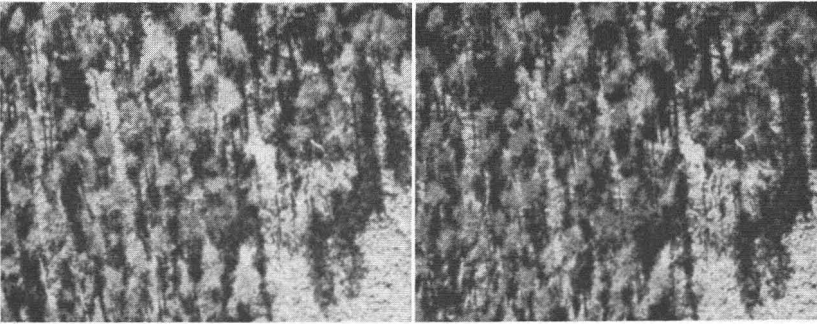


FIG. 11. Large-scale stereogram showing the irregularly rounded, fuzzy crowns of jack pine. Crowns are relatively small and confined to upper portion of trunk. (Scale 1 inch = 50 feet.)

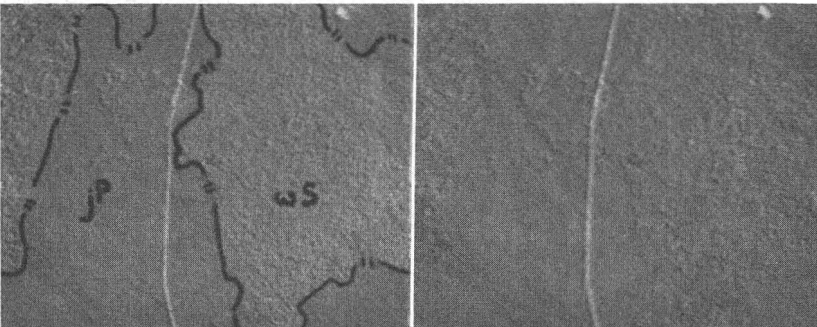


FIG. 12. A pure stand of jack pine (jP) and a pure stand of white spruce (wS). Note the smooth appearance of the jack pine stand and the more ragged appearance of spruce. (Scale 1 inch = 3,200 feet.)

TAMARACK (*Larix laricina*)

Figure 13. Tamarack has a narrow, symmetrical, cone-shaped crown, which in old trees may become broad and irregular. In the fall it is easily distinguished from other conifers by its light tone, which is due to the yellow color of its foliage. In the summer it can usually be distinguished from black spruce, its common associate, by its somewhat broader crown or by its slightly lighter tone. In the winter it can be separated from the hardwoods by its slender, straight, and undivided central stem and by its conical crown shape, which can generally be recognized, even though the

branches and twigs are blurred on photos at smaller scales.

Tamarack is commonly found in swamps, and because it is very intolerant to shade, it frequently grows in the open or, if found under forest conditions, it is usually a dominant with its crown above the general level of the crown canopy.

WHITE SPRUCE (*Picea glauca*)

Figures 6, and 14. White spruce has a single, straight, central trunk which is densely clothed with long branches. Its crown is very dense and symmetrical and in the open grown trees may ex-

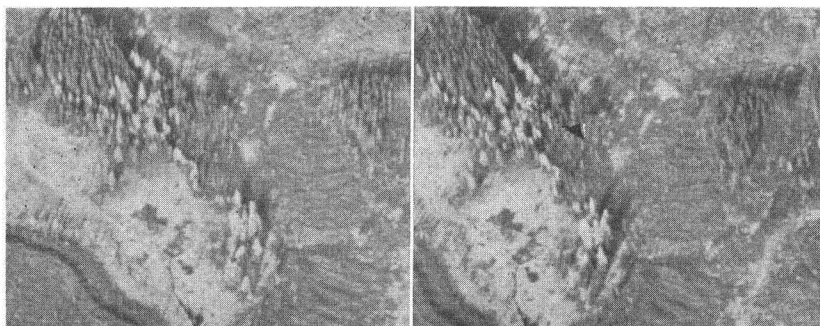


FIG. 13. Oblique, showing tamarack (light toned trees) and black spruce (dark trees). Very light tone of tamarack is due to fall coloring. The crowns of tamarack, on the average, are broader than those of black spruce. (Average scale 1 inch = 200 feet, fall photograph.)

tend nearly to the ground. The apex of the crown generally appears obtuse because the slender tip does not show on the photograph. Northern white spruce presents a different appearance, for its particularly narrow crown and short branches give it a needlelike appearance.

Because of the coarser branching, the crown of white spruce is more irregular than that of balsam fir. Crown shape may also be used to distinguish it from black spruce. This distinction however may sometimes be made by size. Mature white spruce is generally taller than 60 feet, a height which black spruce seldom attains. White spruce rarely occurs in bogs, and it prefers moist but well-drained soils and therefore is commonly found along stream banks or lakes.

BLACK SPRUCE (*Picea mariana*)

Figures 15 and 16. Black spruce usually is a small tree, which seldom attains a height of more than 60 feet, but on very good sites it may be over 100 feet high. It grows on a great variety of sites, but is characteristic of swamps and muskegs. Usually it develops a slender, straight trunk and a very narrow, almost cylindrical crown, which is useful in distinguishing it from white spruce and balsam fir. A dense clump or ball of twigs frequently forms at the top, and it can sometimes be seen on photographs at larger scales. The stems of trees growing in the open are often covered with branches for their entire length. Large trees tend to develop a wider, more irregular and open crown,

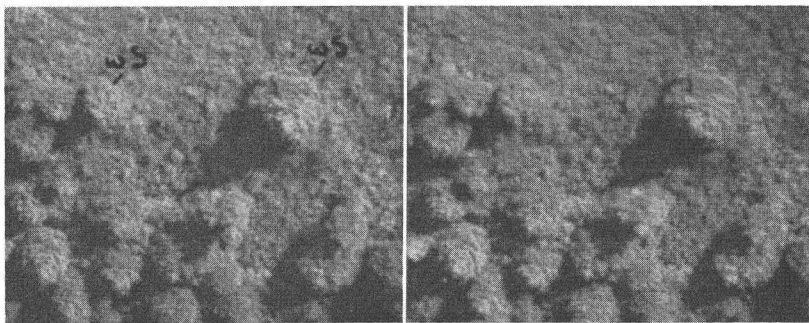


FIG. 14. Large-scale stereogram of white spruce. Note the generally cone-shaped crown and the somewhat blunted top. (Scale 1 inch = 50 feet, summer photograph.)

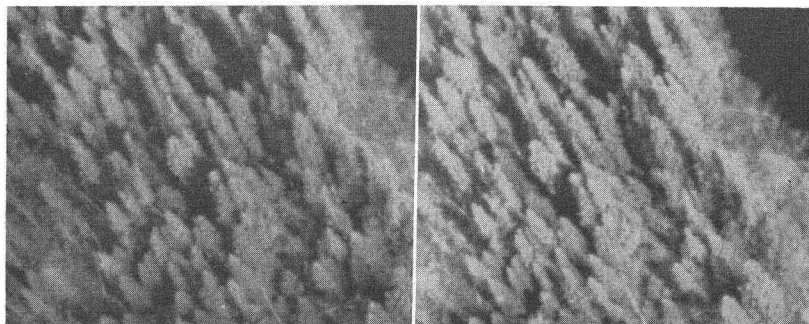


FIG. 15. Black spruce. Note the narrow, often almost cylindrical crowns. (Scale 1 inch = 50 feet.)

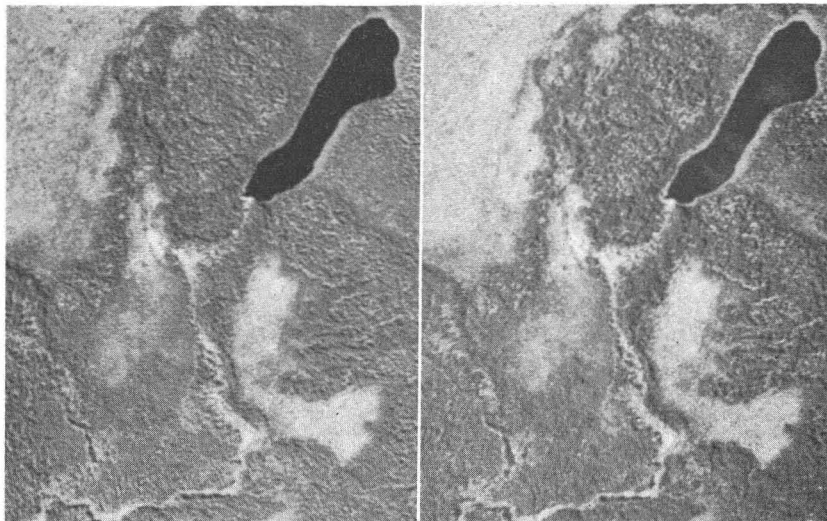


FIG. 16. Pure black spruce. The light toned areas in the left and lower portions of the photograph are open bogs. (Scale 1 inch = 1,320 feet, summer photograph.)

and therefore sometimes cannot be distinguished from white spruce.

Dense black spruce stands appear dark and carpet-like. When cedar is mixed with black spruce, the stand appears mottled, owing to the lighter tone of the cedar crowns.

EASTERN HEMLOCK (*Tsuga canadensis*)

Figure 17. Hemlock develops a broad conical crown which is more obtuse than the crowns of the spruces and of balsam, but more pointed than white pine. Although hemlock may form an irregular and star-shaped crown, resembling white pine, it is usually more regular in outline. Hemlock has very dark foliage and is tolerant to shade. Because of its many twigs and dense foliage, there is a strong contrast between the highlights and the shadows in the crown.

BALSAM FIR (*Abies balsamea*)

Figure 18. Balsam fir has dark foliage and a very dense, narrow, cone-shaped crown of slender branches, which on open-grown trees extend nearly to the ground. It is distinguished by its very symmetrical form and by its characteristically dense,

rigid and spire-shaped tip. The tip often appears very bright on air photographs. The individual branches of balsam fir are less prominent than those of white spruce, and its crown usually appears in a darker tone.

Balsam fir frequently grows in association with white spruce; particularly when white spruce is identified in a mixture with hardwoods, there is an almost certain indication that a significant number of balsam fir trees is present, provided the location lies within the natural range of balsam fir.

EASTERN WHITE CEDAR (*Thuja occidentalis*)

Figure 19. Cedar is usually a small tree which is found in swampy areas or in fields where it often grows in clumps. It is sometimes difficult to distinguish from small, open-grown spruce or balsam fir, although it can usually be identified by its lighter tone and more rounded top. The conical crown is very smooth and, because it is very dense, no large shadows are visible inside the crown, as the case for trees with coarser branching.

Large trees, which may be up to three feet in diameter and 80 feet in height, are rare. The upper part of the crown of such trees is frequently dead,

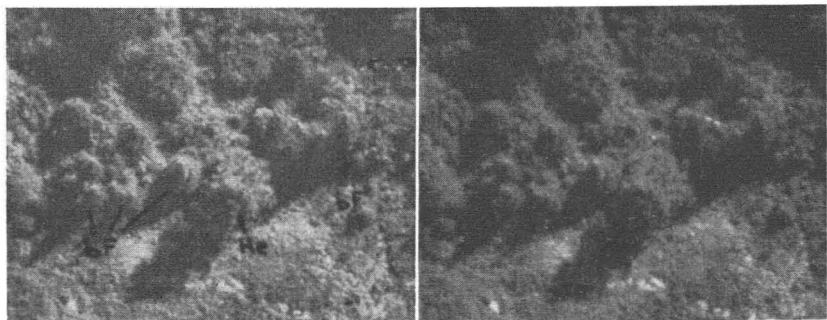


FIG. 17. Hemlock and balsam fir at large scale. The broader and irregular crown of hemlock distinguishes it from the pointed, narrow crowns of balsam. (Scale 1 inch = 50 feet.)

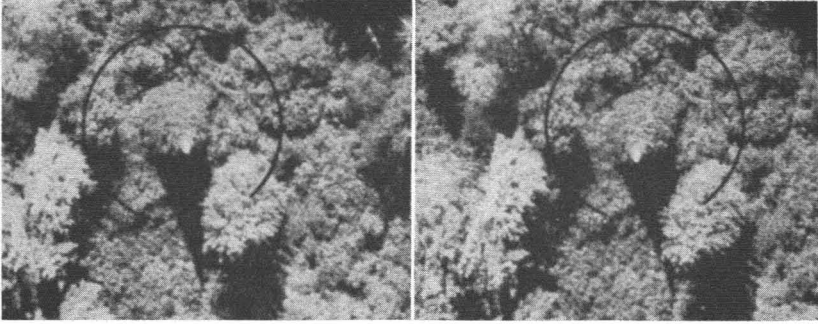


FIG. 18. Balsam fir (circle) at scale of 1 inch = 50 feet. Note the very symmetrical, cone-shaped crown and the spire-like top.

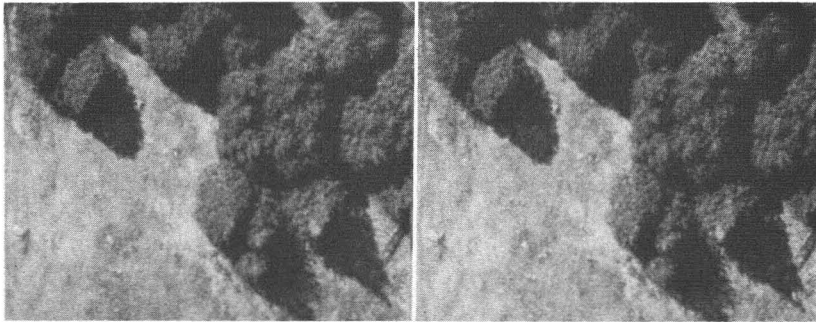


FIG. 19. Eastern white cedar is recognized by its regular symmetrical crown and its rounded top. (Scale 1 inch = 50 feet.)

and then the trunk is seen as a spike above the living crown.

END OF CONIFERS AND BEGINNING OF HARDWOODS

TREMBLING ASPEN (*Populus tremuloides*) AND LARGETOOTH ASPEN (*Populus grandidentata*)

Figures 20, 21 and 22. Trembling aspen and largetooth aspen both have a single, gradually tapering trunk which reaches almost to the top of the crown. The crown consists of relatively few branches and is small, round-topped, and open. Aspen frequently grows in pure stands, which on air photographs are medium or light-toned and show an even, fine-grained texture. Aspen is very

intolerant and if it grows in mixture with tolerant species, it will be a dominant unless finally overtopped. The foliage of aspen is thin and as a result its shadow will usually not be as dark as that cast by hardwoods with dense crowns.

The two species of aspen are very similar; to separate them on air photographs is of no practical importance. Yet this distinction can be made on photographs taken during the period of leafing, because largetooth aspen leafs out significantly later than trembling aspen. Largetooth aspen is also identified because the young leaves, which are covered with a white down, give the crown an almost white appearance on panchromatic air photographs taken a few days after leafing.

Aspen is most difficult to distinguish from white

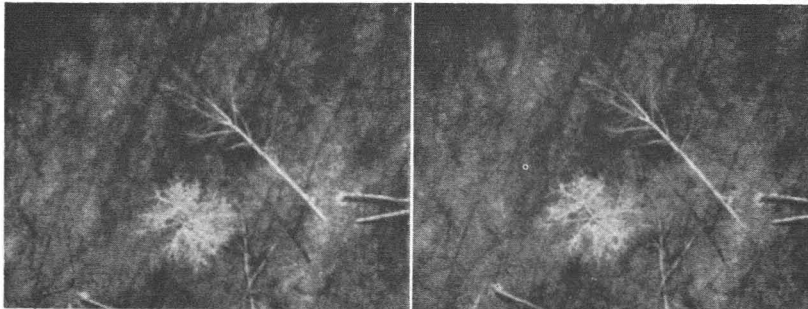
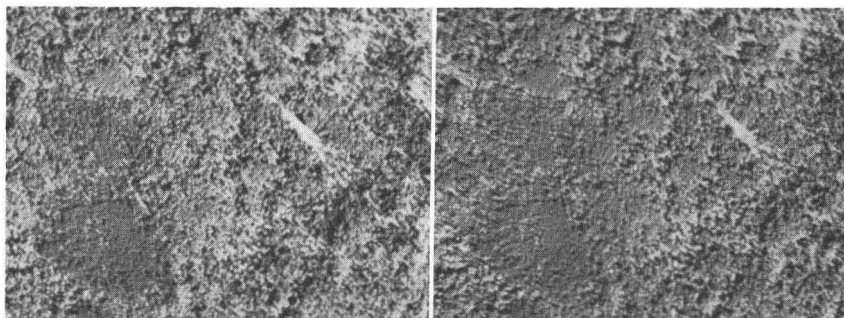
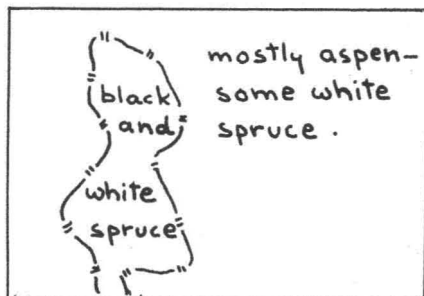


FIG. 20. A standing and a felled largetooth aspen. Note light-colored, gradually tapering trunk, rounded crown, and coarse, light-colored twigs. (Scale 1 inch = 50 feet, spring photograph.)

FIG. 21. Mature aspen. All crowns are of about the same size. They are rounded, and small in relation to tree height. (Scale 1 inch = 1,320 feet, summer photograph.)



birch, a species with which it is frequently associated. The two species are best separated on photographs taken when the leaves have fallen, because then the single trunk of aspen can be distinguished from the usually divided trunk of white birch. White birch may also be identified by its tendency to coppice. Although both species have light-colored bark when compared with other hardwoods, the stems of white birch will show up considerably brighter than those of aspen, which often appear blurred and indistinct on air photographs.

BALSAM POPULAR (*Populus balsamifera*)

Figure 6. Balsam poplar is characteristic of moist soils and therefore is commonly found along rivers and lakes or in rich bottom lands, where it often grows in small pure patches or in association with willow, alder, white birch, spruce and balsam fir. In alluvial flats in the Northwest Territories it often occurs in extensive pure stands.

Balsam poplar has a straight, usually undivided

trunk and a narrow, open, conical crown which is formed by a few stout, ascending branches. Except for very old trees its top is usually pointed. Balsam poplar is very intolerant and will therefore be a dominant when growing in mixture with other species.

WHITE BIRCH (*Betula papyrifera*)

Figures 22 and 23. White birch is an intolerant tree which grows in pure or mixed stands. Young trees have conical crowns, while the crowns of old trees are more rounded and irregular. The trunk, which is characterized by its white color, is commonly forked and divides into a number of large ascending branches.

The white trunk can be used to identify white birch on photographs taken when the leaves have fallen. On such photographs, even at scales as large as 50 feet to one inch, only the trunk and a few main branches will show because the fine, reddish-brown branchlets and twigs are blurred out on the photographs. The result is that the main

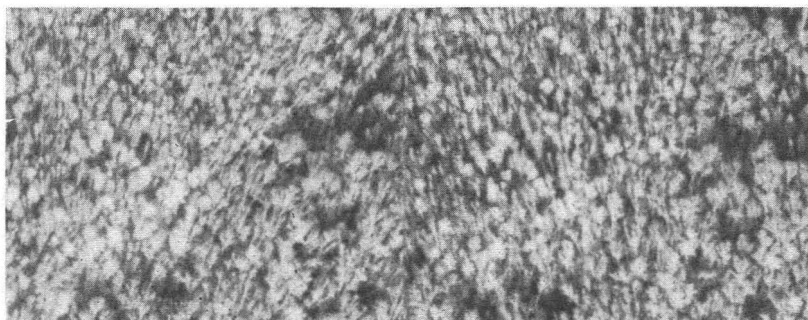


FIG. 22. Oblique, showing aspen and white birch in leafless condition. The trunk of white birch is usually forked, while that of aspen reaches high into the crown. The crowns of aspen appear brighter because of the light color of its twigs. (Average scale 1 inch = 200 feet.)

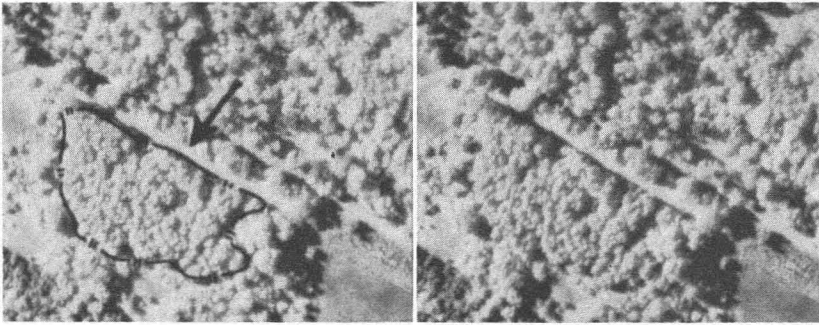


FIG. 23. A pure patch of young white birch coppice (arrow). The crowns are small, and trees grow in clumps. The very light tone of the photograph is due to the use of infrared photography. (Scale 1 inch = 330 feet.)

branches and the trunk appear to be surrounded by a haze. The same effect is not observed on aspen, because the small branches of these trees are coarser and lighter in color. On large-scale summer photographs the white bark sometimes shows through the foliage.

White birch frequently grows in clusters of several stems, often leaning or crooked. On panchromatic summer photographs, its foliage appears in a lighter tone than that of the tolerant hardwoods but is slightly darker than aspen. It is often difficult to distinguish from aspen and some of the characteristics used for this distinction have been given in the description of aspen.

YELLOW BIRCH (*Betula alleghaniensis*)

Figure 24. Except when growing in the open, yellow birch develops a long and massive, well-defined central trunk which supports an irregularly rounded or tufted crown which is often widest near the top. The main branches which are often very coarse and few in number, rise at an acute angle to the trunk and divide to form a hazy twig structure. Yellow birch is less tolerant than sugar maple with which it is often associated, although generally it is found on the moister and cooler locations. The result is that the two species can sometimes be separated by their site requirements. On higher hills, maple more commonly occurs on the upper slopes and ridges, while yellow birch is more characteristic of lower slopes.

A further difference in the appearance of these

two species, which has been observed in several instances on spring and summer photographs, is that yellow birch on panchromatic photographs appears in darker tones than sugar maple.

RED OAK (*Quercus rubra*), WHITE OAK (*Quercus alba*) AND BUR OAK (*Quercus macrocarpa*)

Figures 25 and 26. Under forest conditions red oak develops a tall and straight bole and stout branches which form a solid, round-topped crown. The larger branches are very prominent and tend to show up individually, which on summer photographs gives the crown a billowy appearance. Because of its lustrous, bright-green leaves and its compact crown, red oak reflects much light and appears light on photographs. However, any shadows seen in openings will be very dark.

Losee (8) reports that on panchromatic fall photographs taken near Petawawa in Ontario, red oak appeared darker than any other broad-leaved species. The reason for this may be that oak in the fall turns dark reddish-brown, while other hardwoods in the area, such as birch, aspen, maple and elm, turn yellow or red.

White oak and bur oak develop massive, broad crowns when growing in the open, while in the forest they often have a straight trunk and a smaller crown. The differences from red oak are slight. White oak tends to develop a somewhat smoother crown, while the branching of bur oak is more gnarled and twisted than that of red oak and white oak.

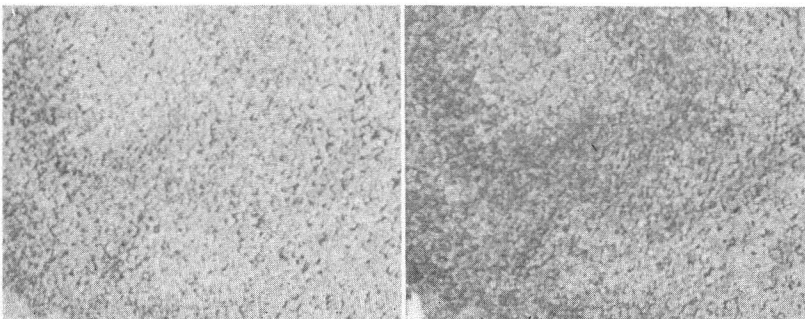


FIG. 24. Summer photograph of a stand of yellow birch and sugar maple. The two species are best distinguished by a slight difference in tone: yellow birch is slightly darker than maple. This distinction is much stronger on the right than on the left photograph, because it is taken from the sunward portion of an air photograph. (Scale 1 inch = 1,000 feet.)

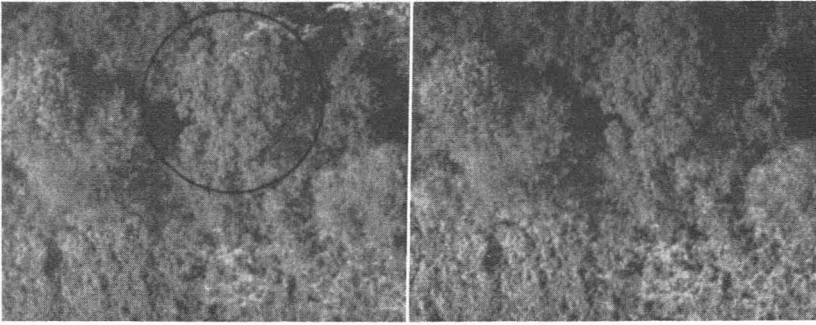


FIG. 25. Red oak at large scale. The crown is spreading, solid, individual branches are prominent. The surface is rough. (Scale 1 inch = 50 feet.)

WHITE ELM (*Ulmus americana*)

Figure 27. When growing in the open elm is easily recognized by its broad and umbrella-shaped crown, which is formed by the gradually spreading, large limbs into which the trunk divides close to the ground. Under forest conditions elm develops a straight trunk, which may be undivided for a considerable height, and it therefore has a less characteristic shape.

Except on large-scale photographs, where the characteristic branching habit can be seen, elm cannot often be identified when growing in a forest, particularly since it seldom forms pure stands. Its more open and often composite crown, however, sometimes can be distinguished from the solid, rounded or billowy crowns of the oaks, sugar maple, and basswood, and by its size it can be separated from aspen and white birch. On panchromatic photographs its tone is darker than that of sugar maple.

White elm often occurs together with silver maple. A feature distinguishing these species is that silver maple has a dense top of fine branches while the main limbs of elm are more spreading, thereby leaving the crown more open.

SUGAR MAPLE (*Acer saccharum*)

Figures 24 and 28. Sugar maple is the most common of the northern tolerant hardwoods; it is the only one which commonly occurs in pure stands. Under the best conditions sugar maple will have a straight trunk which rises to a great height before it divides into several branches. But in the open and on poor sites, its trunk will be short and with many branches. The branches of maple, which are

characteristically slender and ascending, form a rounded, sometimes symmetrical crown. The foliage of maple is very dense, and because of its large and smooth leaves it often shows a lighter photographic tone than elm or yellow birch.

RED MAPLE (*Acer rubrum*)

Figure 29. On poor and dry soils red maple is often a shrub, but on moist and swampy sites it usually attains tree size. In that case it may have a single straight trunk, but quite commonly it will have a divided trunk, or it may grow in a cluster of several stems.

The bigger branches, which grow upward at a sharp angle to the trunk, break up into numerous spreading or ascending branches. In fast-growing trees individual branches protrude beyond the general outline of the crown and give the crown a tufted appearance which is characteristic of this species.

SILVER MAPLE (*Acer saccharinum*)

Figure 30. Silver maple generally grows in moist and swampy locations. Its trunk usually divides near the ground into several ascending, big branches, which form a wide-spreading crown. The smaller branches are slender and the twig structure dense. The bark of young trees and of the branches of old trees is silvery grey.

THE ASHES (*Fraxinus sp.*)

Figure 31. None of the several species of ash which occur in eastern Canada form pure stands. Generally they grow singly or in small groups, and all prefer rich and moist soils.

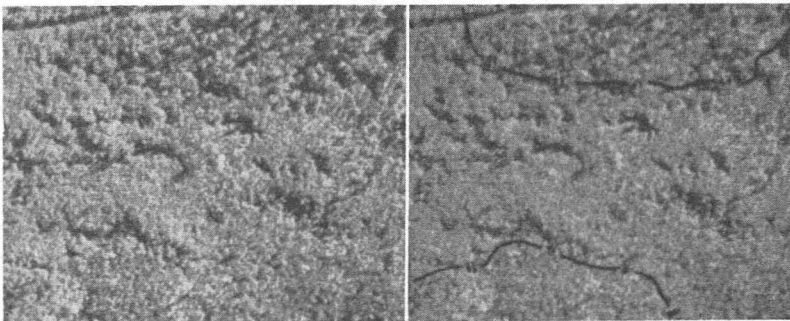


FIG. 26. A stand of red oak is shown between the type lines. Crowns are solid, somewhat billowy and have a rough surface. (Scale 1 inch = 550 feet.)

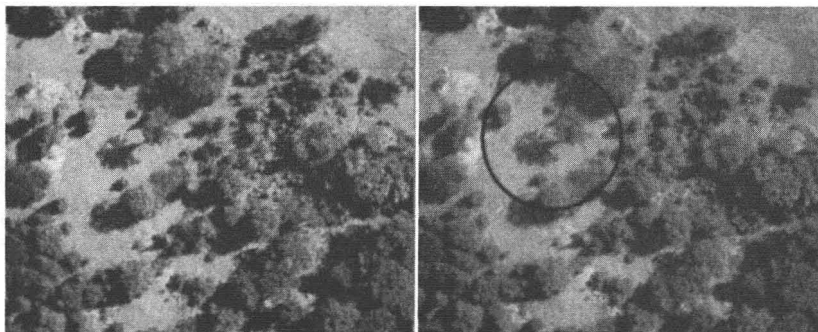


FIG. 27. White elm on summer photograph (circle). The crown is open, spreading and umbrella-shaped. (Scale 1 inch = 200 feet, approx.)

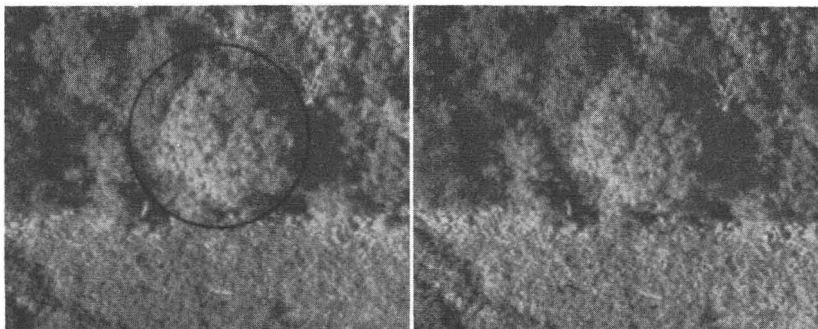


FIG. 28. Sugar maple at large scale. Crown is solid, rounded, and has a fairly smooth surface. (Scale 1 inch = 50 feet.) See also Figure 26.

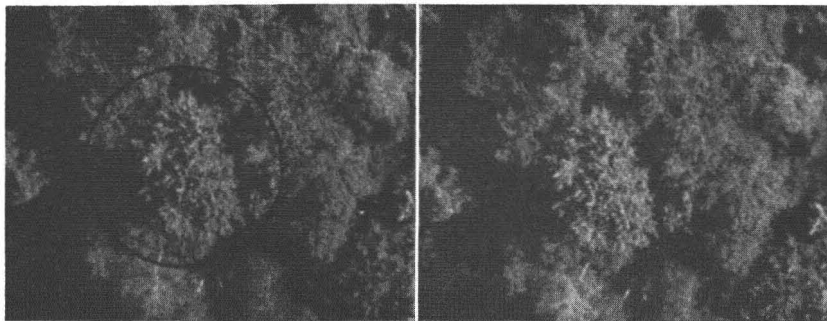


FIG. 29. Red maple. The tufted appearance, which is caused by ascending individual branches, is characteristic of this species. (Scale 1 inch = 50 feet.)

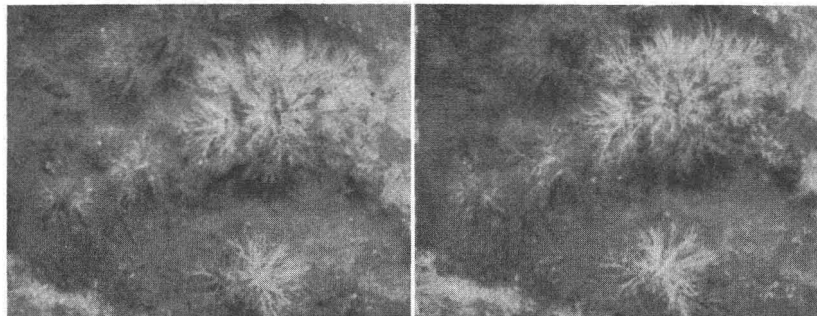


FIG. 30. Silver maple in leafless condition. Note the divided trunk and slender branching. The opposite branching, characteristic of all maples and ashes, is visible in some twigs. (Scale 1 inch = 50 feet.)

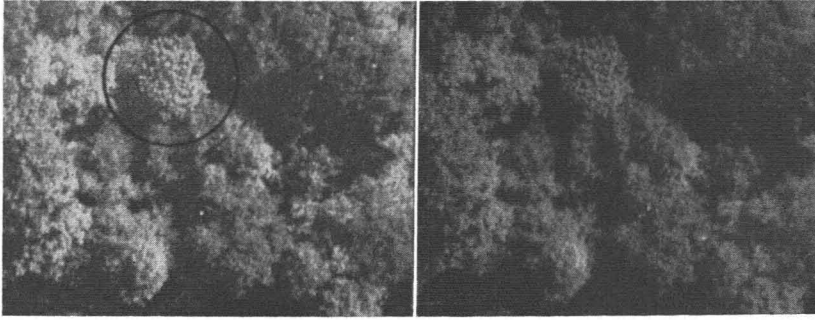


FIG. 31. White ash (circle on left photo) at large scale. The crown is rounded, of medium size, and open. The large leaves can be seen on the original photograph. (Scale 1 inch = 50 feet.)

All ashes, except when growing in the open, usually have straight trunks with little taper, and a medium-sized, shallow, rather open crown, formed by ascending branches. Altogether there is little very characteristic about the crown shape of ash and it remains a very difficult species to identify on air photographs. Black ash can sometimes be identified by its characteristic site requirements, for it often grows in patches in small swamps or other wet areas. Ash is sometimes found in the same locations as elm and silver maple, but it can be distinguished from these species by the fact that it does not have any drooping branches. The photographic tone of the foliage of ash is lighter than that of elm.

BEECH (*Fagus grandifolia*)

Beech is a very tolerant tree commonly associated with sugar maple, from which it is very difficult to distinguish on summer photos. When growing in a stand it develops a massive, straight trunk, which has smooth, grey bark. The lower branches are almost horizontal and these, with their many branchlets, form large, flat sprays. The crown is very wide-spreading and, because of its many fine branches it appears fuzzy and indistinct on winter photographs. The light-colored trunk, however, is the main identifying feature on winter photographs.

BASSWOOD (*Tilia americana*)

Basswood, which never grows in pure stands, develops a tall, clear bole under forest conditions. This bole reaches high up into the crown before it divides into relatively small and short branches. At the larger scales basswood can usually be distinguished from other hardwoods by its very symmetrical, closed, oblong or oval crown, which shows a striking smooth surface. The crowns of overmature trees however will often be open and irregular. Basswood has a tendency to grow from sprouts, which sometimes results in several trees growing in a clump. The crowns of the stems in a clump form a structure that appears as a single, large, symmetrical crown.

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