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AIR PHOTOGRAPHS AND FOREST SITES¹

II. APPLICATION OF AERIAL SITE MAPPING METHODS TO AREAS IN SASKATCHEWAN AND QUEBEC

By S. T. B. LOSEE

*Aerial Surveys Section, Dominion Forest Service,
Ottawa, Canada*

The methods of mapping forest sites from air photographs described in a previous article have been applied to the Pas Working Circle in Saskatchewan and to two areas in Quebec, one near Notakim depot, and the other the Lake Edward Forest Experimental Area.

In mapping the sites of the Pas Working Circle post-glacial geology largely determined the site divisions. Six sites were described and mapped on an area of 900 square miles. Increment data obtained subsequently showed that a correlation existed between diameter growth and the three site divisions represented in it.

A short description of methods applicable to the Notakim Depot and Lake Edward areas is given to show the adaption of the general methods to these particular cases which are representative of large areas in Quebec and New Brunswick.

THE methods described in a previous article (6) and illustrated by application to the Petawawa Forest Experiment Station, have also been applied to an area in Saskatchewan and to two in Quebec. It is the purpose of the present article to show the modifications of method necessary to meet the conditions occurring in the mapping of these additional areas.

SASKATCHEWAN AREA

The area in Saskatchewan is that known as the Pas Working Circle. It extends west from the Manitoba-Saskatchewan boundary near The Pas to Nipawin, and from the summits of the Pasquia Hills on the south to within a few miles of the Saskatchewan River on the north, thus embracing an area of almost 3,000 square miles. Of this, 900 square miles were mapped in detail.

The Working Circle lies within the Manitoba Lowlands, and the mixed-wood sections of the Boreal Forest Region (5) so that the ecological structure of the forests is not complex, or at least is less so than that of the forests on the Petawawa Forest Experiment Station. The number of tree species is small, the communities are related in a simple fashion, secondary successions are few in type and edaphically conditioned in fairly obvious ways.

The topography is not so broken as appreciably to hinder site-mapping. Even the slopes of the Pasquia Hills, which are considerably dissected by numerous stream valleys, may be classified, without serious error, at the scale of four miles to the inch which was the scale of the final map.

The southern part of the area was photographed vertically at a scale of 1200 feet to the inch, and the northern part obliquely. The vertical photographs were taken in the winter, the oblique in the summer. While the

1. The second of two articles on this subject. The first appeared in the September, 1942, issue.

photographs seldom permit the identification of single species, they are excellent for the purpose of differentiating hardwoods and softwoods, even the summer obliques affording clear distinctions between these groups.

The final map was to be on the scale of four miles to one inch and, therefore, only a very broad site classification could be used. Weighing this and the relatively simple ecology of the region against the photographic information available, it was decided that field work could be dispensed with. Assistance in interpretation of the photographs was obtained from the report of Best (1) and Phelps (8).

Working Methods

An outline of a natural site classification for the area, prepared by H. E. Seely (10), was already available, and it was only necessary to fill in the details by a study of the area from the air photographs in the light of the geological and ecological information available. The following classification was the result:

1. Plateau site
2. Glacial Slope site
3. Delta site
4. Lacustrine site
5. Lowland site
6. Fluvial site

These are in the natural order from the highest topographical situation to the lowest, with the exception of the Fluvial site, which is not readily classified in this way. From the standpoint of productivity the order from best to poorest is:

1. Fluvial site
2. Lacustrine site
3. Glacial Slope site
4. Delta site
5. Plateau site
6. Lowland site

Geology

The geological events of the past have determined not only the topography, but the nature of the soil of the Pas Working Circle and, therefore, within the climatic limitations, the whole complex of edaphic factors. The first event of major importance was the deposit of thick layers of sand and clay in the cretaceous sea which covered this part of the continent. The sandstones and shales subsequently formed from these deposits were elevated and, through erosion at their eastern edge where they met the precambrian rocks, a high plateau took shape which now rises gradually westward to 4,000 feet at the foot of the Rockies on the International border. This is well described by Upham (13). Further erosion fretted great river valleys into this eastern edge, leaving residual elevations between them. Among these are the Tiger Hills, Duck Mountain, Riding Mountain, the Porcupine Hills and the Pasquia Hills, which last form part of our area. During the pleistocene, the continental ice-sheets advanced and retreated over this whole region at least four times according to Coleman's recapitulation (2) of modern investigations.

Little is known of the first three glaciations and most of their effects upon site conditions have been blotted out by the work of the last ice sheet, the Wisconsin. As the ice face began to recede, its load of till was left undisturbed on the uplands but sorted and waterwashed wherever glacial lakes were formed or glacial streams flowed. At the same time, the drainage of Manitoba and Saskatchewan, which should have gone northward to Hudson Bay, was blocked by a wall of ice thousands of feet high, while the heights of land to the south were relatively higher than at present, because of the depression of the northern parts of the continent under the weight of the vast ice sheets. As a result, the water from the melting ice and from ordinary precipitation was impounded in this huge basin and Lake Agassiz was formed. In the Pas Working Circle this lake flooded the lowlands of the Carrot and Saskatchewan Rivers and washed against the Pasquia Hills. Sediments accumulated on the lowlands and sandy or gravelly beaches with frequent delta deposits of coarse sand along the hills. The lake receded stage by stage, as successively lower outlets were opened by the continued recession of the ice. Ultimately it was entirely drained and the Carrot and Saskatchewan Rivers with their tributaries began cutting channels through the accumulated sediments of the lake bed. Because these sediments were deposited on undisturbed cretaceous shales and sandstones (12), the lake bed was flat, and the rivers meandered greatly, with consequent abandonment of numerous channels and the excavation of cross-channels such as the Sipanok.

All the geological features produced by these events—the old lake bed with its meandering rivers and channels, the beach lines and deltas, the till-covered slopes and plateau of the Pasquia Hills—are readily identifiable in the air photographs and have much significance for site evaluation as will appear in the section describing the site classification adopted.

Zonation

The geological history of the region has determined the zonation, which, as broadly conceived, is without variation, for a similar topographic situation invariably has similar general site conditions. The only possible complication is caused by the mosaic of lowland and fluvial sites, described below.

Visible Characteristics of the Vegetation

In view of the ecological and topographical condition of the area to be mapped, and the scale of the map to be produced, it was only necessary to distinguish between hardwoods and softwoods, which was readily done. It was, however, of some help to utilize the distinction between jack pine and the tolerant conifers found in the lesser density of the jack pine foliage, which gives stands of jack pine a greyish tone in the winter photographs. The characteristic appearances of muskeg areas and of willow scrub were also useful in assigning such areas to the proper site class.

Site Classification

1. **Plateau Site.** The plateau has but small variations in elevation from point to point. These small elevations are not sufficient to provide drainage of the clay soil which has, therefore, become waterlogged. Only on the higher of these elevations can trees reach commercial sizes. Black spruce

predominates, with scattered white spruce occurring on the highest knolls.

2. **Glacial Slope Site.** On the slopes of the hills above the highest beach line the soil is still glacial till with much clay but the rather steep slopes give excellent drainage and tree growth is good. Hardwoods rather than softwoods, however, are characteristic of these slopes at the present time, although good spruce is scattered throughout, much of it in gullies cut into the clay by streams.

3. **Lacustrine Site.** Below the highest beach line on the slopes of the Pasquia Hills, and above the water-logged soils of the old lake bottom, extends a strip of soil which received the benefit of the sediments from Lake Agassiz and yet has sufficient slope for drainage. It has, therefore, better growth conditions than the Glacial Slope site.

4. **Delta Site.** At each level of Lake Agassiz, as it receded by steps, deltas were formed at the mouths of the streams entering the lake. These deposits are, of course, quite sandy and present a marked contrast in habitat conditions to the Lacustrine site. Commonly they support a good growth of jack pine. In absolute site value they rank below the Glacial Slope site, but above the Plateau site and the Lowland site (No. 6).

5. **Fluvial Site.** This site derives its name from the origin of its soil, which has been deposited by streams and rivers during high water periods. Much of it is brought from the Rockies by the Saskatchewan River and, being largely derived from limestones and dolomites there, assists greatly in improving soil fertility by neutralizing the tendency of northern soils to form raw humus as well as by increasing the supply of essential minerals. This material forms natural levees built above the level of the surrounding country and extending as much as a mile from the watercourse. The area between the Carrot and Saskatchewan Rivers is criss-crossed with a network of new and old channels, each with its levees, so that an appreciable part of it now lies above the level of the original lake deposits and is, therefore, well drained. These fluvial deposits form the most fertile soil of the Working Circle. Both hardwood and softwood species here show their best growth.

6. **Lowland Site.** In the interstices of the network of fluvial soils lie the original sediments of Lake Agassiz. Because of the flatness of the old lake bed, the underlying till and the impediment of criss-crossing ridges formed by the fluvial deposits, these soils are practically undrained and are either treeless or, at best, support only a poor growth of black spruce. This is quite the poorest site in the Working Circle.

Summary

The following summary shows briefly the means adopted of recognizing each site:

- I. Stands of pure softwood,
 - A. Thin crowns producing greyish tones in winter photographs; Stands deltoid in outline, situated below former beaches; closed stands.....Delta site
 - B. Heavy crowns producing dark tones in winter photo-

graphs; many areas of open muskeg

1. Plateau Top Plateau site
2. Saskatchewan—Carrot River lowlands..... Lowland site
- II. Stands of pure hardwood, Pasquia Hills..... Glacial Slope site
- III. Mixed stands, or small areas of hardwoods and conifers intermingled
 - A. On natural levees of present or abandoned stream courses Fluvial site
 - B. Below highest Agassiz beach, but without large muskeg or brush areas Lacustrine site

Results

Data from plots which were analysed by Mulloy (7), after the site classification from air photographs had been made, supported the divisions drawn. For example, increment data from these plots showed that white spruce 12 inches D.B.H. in the coniferous type required 6 years to grow one inch on the Fluvial site, 7.5 years on the Lacustrine site and 8.3 years on the Glacial Slope site. Other diameters showed similar differences. No plots were taken on the other sites, since the total area of the Delta site is quite small and the commercial importance of the Lowland and Plateau sites is negligible.

QUEBEC AREAS

NOTAKIM DEPOT

Notakim Depot lies about 80 miles north of Maniwaki on the limits of the Canadian International Paper Company. While engaged in a field study for the Dominion Forest Service in co-operation with this Company, the writer took advantage of the opportunity to make the field studies necessary for mapping the site-types of the area from air photographs. The actual mapping has not yet been done but the methods worked out for it are here presented to show another modification of the detailed methods described in the first article (6). In this case field investigations were made but no geological correlations were necessary. The photographic and ecological conditions are in the same general class as those of the Pas Working Circle but the proposed mapping scale is 20 chains to an inch.

Ecological Conditions

The ecological conditions of the area are relatively simple. Five site-types were established by Dr. Heimbürger, and each of them is closely related to the topography. The crown-cover characteristics of the various site-types are also sufficiently diverse to provide additional means of identification in the photographs. The site-types are:

- a. Viburnum site-type (ridge tops)
- b. Aster-Acer spicatum site-type (upper slopes)
- c. Calliargon-Cornus site-type (lower slopes)
- d. Kalmia-Ledum site-type (valley bottom)
- e. Sphagnum site-type (valley bottom)

Photographic Information

Good summer photos at 1200 feet to the inch cover the entire area. The scale and photographic quality are sufficient to distinguish clearly hardwoods from softwoods, and also the small- from the large-crowned species groups.

Field Work

The field work was done in the intervals of other work over a period of six weeks. In all it was about the equivalent of 12 man-days. With the photographic information available, this was sufficient to establish mapping methods of the desired accuracy for this area.

The Methods

1. The Use of Topography

The five site-types occupy topographical situations which are sufficiently distinct from one another to be used in the identification of the respective site-types.

a. **Viburnum Site-Type.** This type occupies only on the highest ridge tops.

b. **Aster-Acer spicatum Site-Type.** This type is found only on the middle and upper slopes.

c. **Calliergon-Cornus Site-Type.** The lower slopes are the usual habitat of this type but it is also found in undrained hollows formed in terraces on the hill slopes or on the summits. The extent of the zone of Calliergon-Cornus type when it occurs on the lower slopes depends upon the rapidity of the change of slope from the hillside to the valley floor. If the change is gradual, this zone is broad; if abrupt, the zone is narrow and in extreme cases may be too narrow to map.

d. **The Kalmia-Ledum Site-Type** occupies the more elevated portions of the valley bottoms.

e. **The Sphagnum Site-Type** is found in the lowest parts of the valleys, along water courses and lake shores and in undrained depressions in the hills.

2. The Use of Zonation

The site-type zonation is shown by the list of site-types just above. This order is invariable with the average uninterrupted slopes. The existence of unusually steep terraces, unusually gradual slopes, gullies, or other interruptions to the smooth slope will cause alterations which, however, will be recognized with experience when the topography is studied under the stereoscope. This order, then, may be relied upon and having determined the location of one site-type the remainder of the zonation may be confidently predicted according to the topography.

3. Tree Cover Characteristics

Specific identification was rarely possible with the photographs available but softwood species as a group could be distinguished from the hardwood species by their darker tone and shape of crown. (The use of crown shape

is possible because of the great predominance of balsam fir and spruce.) The hardwood species were sub-divided into the large-crowned yellow birch and sugar maple group, and the smaller-crowned poplars and birches. Both sub-divisions have considerable diagnostic value. The *Viburnum* site-type has very few softwoods; the *Aster-Acer spicatum* has a mixed cover-type, the *Calliergon-Cornus* has a little white birch with the prevailing conifers of its tree-cover, and the remaining two site-types support softwood stands. The arrangement of crowns in these softwood stands (*Kalmia-Ledum* and *Sphagnum* site-types) is frequently distinctive. On the *Sphagnum* site-type the crowns of the black spruce are widely and irregularly spaced. On the *Kalmia-Ledum* site-type mixed spruce and jack pine give an extremely dense crown cover, particularly in the earlier stages of the succession from jack pine to spruce.

4. Summary

The means of identifying the site-types of the Notakim area have been brought together and defined as strictly as possible in the key which follows:

- I. Stands with less than 10 per cent crown area in hardwoods:
 - A. Pure softwood, only occasional hardwood crowns
 1. Occupying lowest-lying situations in small or large valleys, also along water-courses and beside lakes; crown cover irregularly open.....*Sphagnum* site-type
 2. Occupying the higher portions of valley floors; crown cover frequently very dense.....*Kalmia-Ledum* site-type
 - B. Five per cent or less hardwood crown area; on lower slopes of hills; adjoins *Aster-Acer spicatum* site-type....
Calliergon-Cornus site-type
- II. Stands with 20 per cent or more in hardwood crown area
 - A. Hardwood crown cover 20-80 per cent; crowns smaller than those of tolerant hardwoods; middle and upper slopes; lies between *Calliergon-Cornus* zone and *Viburnum* zone*Aster-Acer spicatum* site-type
 - B. Hardwood crown cover 80-100 per cent; many large crowned hardwoods; occurs on ridge summits only; *Aster-Acer spicatum* zone lies immediately below.....
Viburnum site-type

LAKE EDWARD FOREST EXPERIMENT AREA

Since, according to Heimburger (3), the Lake Edward Forest Experiment Area is representative of the site types of large areas of Quebec and northern New Brunswick, the data reported by Heimburger (4), Ray (9), and Sisam (11) were studied with a view to evolving an outline of suitable air survey methods for site-types of this area. This was greatly facilitated by the site-type map of the Forest Experiment Area, prepared by Ray (9), which permitted correlation of topography and vegetation characteristics with site-types without field studies, though these will be necessary to test the application of the correlation to the whole area represented.

Ecological Conditions

Four site-types cover 94 per cent of the area and two more (the swamp types) the remaining 6 per cent according to Ray (9). The ecological conditions are, therefore, even less complex than in the Notakim area. The following list taken from Ray's report (9) gives the types and percentage of the area covered by each:

a. Viburnum site-type	2 per cent
b. Viburnum-Oxalis site-type	20 per cent
c. Oxalis-Cornus site-type	62 per cent
d. Cornus site-type	10 per cent
e. Kalmia-Ledum site-type	6 per cent
f. Sphagnum-Oxalis site-type	
	<hr/>
	100 per cent

Photographic Data

The northern half of the area has been photographed at a scale of 800 feet to the inch, the southern at 1,200 feet to the inch, both halves during the summer. Tone distinctions in the northern flights are unusually good but rather poor in the southern. In combination, however, they are sufficiently clear for accurate work and correspond very well with average summer photos taken on a scale of 1,200 feet to the inch.

Methods

1. The Use of Topography

Each site-type described in this area has a definite topographical relationship as Heimburger (4) has pointed out. The following quotations are all from page 22 of this publication:

a. **Viburnum Site-Type.** "The Viburnum type occupies those hill-tops with a shallower layer of unmodified glacial till," (i.e., shallower than that of the Viburnum-Oxalis Type.)

b. **Viburnum-Oxalis Site-Type.** "The Viburnum-Oxalis type is found on the upper parts of the hill slopes and on some hill-tops with deep unmodified glacial till."

c. **Oxalis-Cornus Site-Type.** "The Oxalis-Cornus type occupies the lower portions of the hill slopes and the flats between these."

d. **Cornus Site-Type.** "The Cornus type is confined to rocky ledges and lake shores with a somewhat shallow soil which, as a rule is water-washed."

e. **Kalmia-Ledum Site-Type.** "This type is found on the shallow alluvial deposits in some of the side valleys draining into Lake Edward."

For practical mapping, the relationship between site-type and topography

Figure 1. Lake Agassiz beach lines. These beach lines are ridges of sand and gravel thrown up by the wave and ice action of the lake at each level at which the lake remained for an appreciable period. The ridges are revealed in the photograph by differences in tree growth, which is less luxuriant on the sand and gravel beach line, than on the clay prevailing elsewhere.

Fig. 2.

should be studied in detail so that the exceptions to the general correlations made by Heimburger may be discovered and means found to recognize them under the stereoscope.

2. The Use of Zonation

In the case of the Lake Edward area, where each site-type is so closely tied to a particular part of the topography, it appears unnecessary with the available data to consider zonation as a separate means of identification. Field examination may, however, alter this for the larger area.

3. Crown Cover Characteristics

a. Viburnum Site-Type. The presence of sugar maple, yellow birch and beech, with their relatively large crowns, and the small representation of conifers, is diagnostic for this site-type in the air photographs. Ray's report (9) gives 3,641 cubic feet of hardwoods and 138 cubic feet of softwoods per acre.

b. Viburnum-Oxalis Site-Type. This site-type also has a large proportion of maple, yellow birch and beech growing on it but it is a smaller proportion than on the Viburnum site-type. Ray (9) reports 2,126 cubic feet of hardwoods and 672 cubic feet of softwoods per acre.

c. Oxalis-Cornus Site-Type. On this type the softwoods are more prominent than the hardwoods. Ray's figures (9) for volume illustrate this: hardwoods 1,003 cubic feet per acre; softwoods 1,454 cubic feet per acre.

d. Cornus Site-Type. The crown-cover on this site is predominantly coniferous, but with sufficient white birch in its make-up to distinguish it from the purely coniferous crown-cover of the Kalmia-Ledum site-type. Ray's figures (9) are 294 cubic feet of hardwoods and 1,506 cubic feet of softwoods per acre.

e. Kalmia-Ledum Site-Type. Black Spruce forms the typical stand on this site-type in the Lake Edward area, together with scattered individuals of white pine and balsam. The site-type is therefore easily picked out on photographs from this area. Jack pine, found on such sites in the Notakim area, is absent for its range lies north of the area under consideration.

f. Sphagnum-Oxalis Site-Type. The crown-cover of the stands on this site-type is very open because of the large proportion of ground which is occupied by alders. Both hardwood and softwood species are scattered throughout. This produces a characteristic crown-cover which can be readily recognized in the photographs.

4. Summary

As in the case of other areas, the means of identifying the site-types

Figure 2. Sites in the Pas Working Circle.

1. Plateau site
2. Glacial Slope site
3. Lacustrine site
4. Fluvial site
5. Lowland site

Cutting is evident on both the Lacustrine and Fluvial sites.

from air photographs has been summarized in the form of a key as follows:

- I. Stands with less than 30 per cent of the crown cover composed of hardwoods
 - A. Pure softwood, only occasional hardwood crowns, situated in depressionsKalmia-Ledum site-type
 - B. As much as 20 per cent hardwood in the crown cover; situated on rocky ledges, lake shores, and swamp borders; adjoins Kalmia-Ledum or Sphagnum-Oxalis types.....
Cornus site-type
- II. Stands with more than 30 per cent of the crown cover of hardwoods
 - A. 30 to 50 per cent hardwood in all; occupying lower slopes and adjoining flats: bordered on the upper side of slopes by the Viburnum-Oxalis site-type.....Oxalis-Cornus site-type
 - B. Hardwood crown cover 60 to 100 per cent in all.
 1. Hardwood crown cover 60-90 per cent of the total; occupying upper slopes and occasional hill-tops above Oxalis-Cornus site-typeViburnum-Oxalis site-type
 2. Hardwood crown cover 90 per cent or more of the total; occupying hill-tops only, above the Viburnum-Oxalis site typeVirburnum site-type

APPLICATIONS

Sites determined and mapped from air photographs may be used to reduce the cost and improve the sampling of growth rate surveys. If maps showing the individual sites are first prepared, each site-area, or a representative portion of each site, can then be sampled, care being taken to include all the cover-types and age-classes occurring. Both increased accuracy and reduced cost should be obtained in this way.

For areas about to be placed under intensive management, site mapping from air photographs provides a cheap means of determining the ecological conditions in various parts of the area. The silvicultural treatments required for the area as a whole then may be planned and the costs estimated.

In forest research of any nature it is essential to work with biological units if the results are to be intelligible and applicable to areas other than the one from which they were obtained. Here also the air survey method provides a means of mapping such biological units, thus allowing the selection of a series of uniform or diverse areas as experimental requirements dictate, without the enormous loss of time resulting from ground location.

Finally, the mapping of absolute site classes is equivalent to land classification. The same methods that have been described for distinguishing various types of forest land can be applied to distinguishing forest land from agricultural land, and the various qualities of each. With various land settlement plans being developed to meet post-war conditions, the air photographic methods should find a wide application. The reduction in cost and saving of time made possible by those methods should also encourage the preparation of more detailed land classifications than would be feasible if the expensive ground methods only were available.

CONCLUSIONS

The following statements embody the major conclusions reached by the writer at the present stage of his investigations:

1. Air photographs can be successfully used to identify and map absolute forest sites.
2. Either a topographic or a vegetative site-type basis may be used.
3. The combination of field and photographic information must be adapted to the topography and ecology of the area.
4. The classification of areas according to their inherent growth-producing qualities is tantamount to land classification.

References

- (1) Best, A. L. Report on survey of cut-over lands, Carrot River, Saskatchewan, 1936. Unpublished report, Dominion Forest Service.
- (2) Coleman, A. P. The last million years. University of Toronto Press, Toronto, 1941.
- (3) Heimbürger, C. C. Report on a trip to Gaspé, New Brunswick, and Quebec. Research Note No. 49. Dominion Forest Service. 1936.
- (4) Forest-site classification and soil investigation on Lake Edward forest experimental area. Silvicultural Research Note No. 66, Dominion Forest Service. 1941.
- (5) Halliday, W. E. D. A forest classification for Canada. Dominion Forest Service Bull. 89. 1937.
- (6) Losee, S. T. B. Air photographs and forest sites. I. Mapping methods illustrated on an area of the Petawawa Forest Experiment Station. For. Chron. 18:3:128-144.
- (7) Mulloy, G. A. Budget determination for the Pas Working Circle. Unpublished report, Dominion Forest Service. 1940.
- (8) Phelps, V. H. Growth and reproduction of white spruce on cut-over areas of the Pas Lumber Company, in northern Saskatchewan. Unpublished report. Dominion Forest Service. 1938.
- (9) Ray, R. G. Site-types and rate of growth, Lake Edward, Champlain County, P.Q. 1915 to 1936. Silvicultural Research Note No. 65, Dominion Forest Service. 1941.
- (10) Seely, H. E. Report on the mapping of the Pas Lands from air photographs. Unpublished report. Dominion Forest Service. 1935.
- (11) Sisam, J. W. B. Correlating tree species and growth with site-types, Lake Edward, 1937. Unpublished report, Dominion Forest Service. 1937.
- (12) Tyrrell, J. B. Report on north-western Manitoba with portions of the adjacent districts of Assiniboia and Saskatchewan. Annual Report Geological Survey of Canada, Volume V, 1890-1892, Part E.
- (13) Upham, Warren Report on the exploration of the glacial lake Agassiz in Manitoba. Annual Report Geological Survey of Canada. 1888-1889 Part E.