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A FLORISTIC STUDY OF COOK COUNTY, NORTHEASTERN MINNESOTA[1]

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"The face of the country offers a wild scene of huge hills and rocks, separated by stony vallies, lakes and ponds. Wherever there is the least soil, it is well covered with trees."

Alex. Mackenzie.

Mackenzie's (1802) succinct characterization of the Border Lakes country of Cook County, although cast in the romantic verbiage of another century, describes this region as it still exists today (Plate 1190-A). Mackenzie was travelling by canoe along the old fur-traders' route between Grand Portage (Fig. 1), the famous fur-trading center, and the height of land. He was by no means the first white man to visit the region—it had been known and the route had been in use for over a hundred years before his time (*cf., inter alia,* Nute 1941 and 1944).

The writers' interest in Cook County was initiated when Dr. Butters discovered certain of the floristic rarities of Lake Superior at Grand Portage in 1927. These rarities had long been known from the adjacent Thunder Bay and Algoma Districts of Ontario, thanks to Louis Agassiz's canoe expedition of 1849 (Agassiz, 1850). The collections of Juni (1879) and of Roberts

[1] The Graduate School of the University of Minnesota has, since 1938, periodically supported the field work upon which this study is based; it also awarded the junior writer a Faculty Summer Research appointment, second summer session, 1947, to permit the rewriting of Sections 9–12. Completed with aid from the National Science Foundation (Grant NSF-G111).

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[2] The untimely death of Fred K. Butters in 1945 (*cf.* Abbe, 1948) left Sections 1–11 unwritten, although Section 12, the Annotated List, was virtually complete at that time. The junior author has attempted to embody in Sections 1–11 the essence of many conversations with Dr. Butters, but must accept full responsibility for all errors of omission and commission.

(1880) extended the known range of these floristic elements along the North Shore of Lake Superior into Minnesota, and focussed attention on "The Point" at Grand Marais. It had also been known for some time (*cf.* Cooper, 1913; and Brown, 1937) that Isle Royale also shared in the presence of these floristic curiosities. Although Fernald (1925) in his classical phytogeographical study seemed to have established a comprehensive hypothesis—the "Persistence" theory—to explain the presence of such oddities in the flora of eastern boreal America, doubts began to develop. Dr. Butters' skepticism of the "Persistence" theory had its roots in his studies of the Selkirk flora (Butters, 1914); that of the junior writer in his study of the flora of northeastern Labrador (1936). In 1937 the writers presented an oral report (Butters and Abbe, 1937) on the flora of Cook County based on their field work of 1936 and 1937, and there raised questions concerning relations of the flora to the history of the Pleistocene in the area. It is impossible to attribute the presence of any plants in the county today to "survival"—the necessary "refugia" do not exist. The present paper is the culmination of the work reported in 1937, extended to include a catalogue of the vascular plants of Cook County. It is organized into twelve sections as follows:

1. Surface Features
2. Geological Features
3. Climate
4. Summary of environmental conditions in Cook County
5. General Features of the Flora and Vegetation
6. The localized habitats and their plants
7. Presumed history of the flora of Cook County
8. Comparison with other presumed "nunatak" areas
9. The botanical exploration of Cook County
10. Summary of major collections from Cook County
11. Place names in Cook County
12. Annotated List of Vascular Plants of Cook County

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1. Surface Features[3]

Cook County, as part of the Arrowhead region of northeasternmost Minnesota, falls at the western limits of the great Laurentian Upland. The relief in the county is the greatest for any part of the state, ranging from the shores of Lake Superior (602 ft.) to the tops of the Misquah Hills (2230 ft., maximum elev.) in the central part of the county (Fig. 2 A).

A number of more or less isolated "mountains"—the Sawteeth Mountains—mark the southern edge of the rolling tableland which constitutes the greater part of the county. The easternmost of these hills is Mount Josephine and one of the westernmost, Carlton Peak. The Sawteeth Mountains rise rather abruptly from the shore of Lake Superior to slightly above the level of the extensive tableland whose elevation is about 1500 feet.

On the abrupt rise from the lake to the tableland there occur many raised beaches interspersed among the numerous wave-cut cliffs. These features represent the abandoned shorelines of the late-Wisconsin predecessors of Lake Superior. The beaches are more frequent in the eastern part of the county; they are variously composed of gravel, shingle, and cobbles, as are the present beaches. There are very few sand beaches along the present northwestern shores of Lake Superior, the shores in general being too abrupt and rocky to favor their establishment.

The rolling topography of the tableland is reflected in the drainage (Fig. 1). The streams and rivers of the southern part of the tableland flow gently southward in shallow valleys, interrupted occasionally by lakes until they reach the edge of the tableland. Here they tumble precipitately over the edge of the tableland. From the edge of the plateau to the level of Lake Superior short but deep canyons have been formed by this active stream action.

The height of land between the Lake Superior drainage and the Hudson Bay drainage runs diagonally across the western portion of the tableland (Fig. 1). There is, however, but little difference in aspect between the two portions of the tableland on either side of the height of land.

The northeastern part of the tableland is markedly different from the rest (Plate 1190-A). The streams and deep lakes (100–

[3] See fig. 1 and 2.

200 ft.) here lie in the Pigeon River drainage which is part of the Lake Superior system. Both the rivers and the lakes have a predominantly east-west orientation and there is a striking cuesta type of topography (*cf.* Fig. 2 B). Associated with the latter there are numerous shady north-facing cliffs which often rise several hundred feet above the lakes at their bases. Extensive talus slopes are usually formed at the bases of these cliffs. Smaller cliffs have in many places been engulfed by the encroaching and finally stabilized talus. The talus of the larger cliffs, on the other hand, is still growing slowly due to occasional rock falls as weathering of the cliff faces continues. At the bases of the great talus slopes are rectangular diabase blocks eight or ten feet on a side, while farther up the slopes the blocks become smaller and may give way to elongate shards of slate; at the bases of the rock walls of the cliffs the soil is a finely comminuted rock. The diabase trap sills which form the caps of the north-facing cliffs slope gently southward to the next chain of lakes. These are set off by yet another series of north-facing cliffs, a sequence which is repeated until the southern limit of the Rove Slate area (Fig. 2 C) is reached.

According to earlier estimates (*cf.* Leverett and Sardeson, 1917) fully 25% of the 1680 or so square miles of the surface of the county is occupied by lakes (Fig. 1) and muskeg. This is probably too low a value, but a more accurate estimate awaits evaluation of the aerial survey maps. The muskegs and swamps are especially abundant on the greater part of the upland and in the lowlands at the eastern end of the county. These muskegs are often intimately associated with existing lakes, both occupying rounded basins formed in the underlying rock and morainic materials. In the Rove Slate area, muskegs are, however, very infrequent, the deep V-bottomed lake basins being poorly adapted to muskeg development.

Unlike most of the rest of the state there are extensive areas of bare rock exposed in Cook County. The higher hills are generally rocky and scoured by glacial action and there are many intervening areas of exposed rock. Many of the streams entering Lake Superior have cut down to bed rock in the more precipitous portions of their courses. Notable rock exposures also occur in the great cliff faces of the Rove slate area (Plate 1190-A).

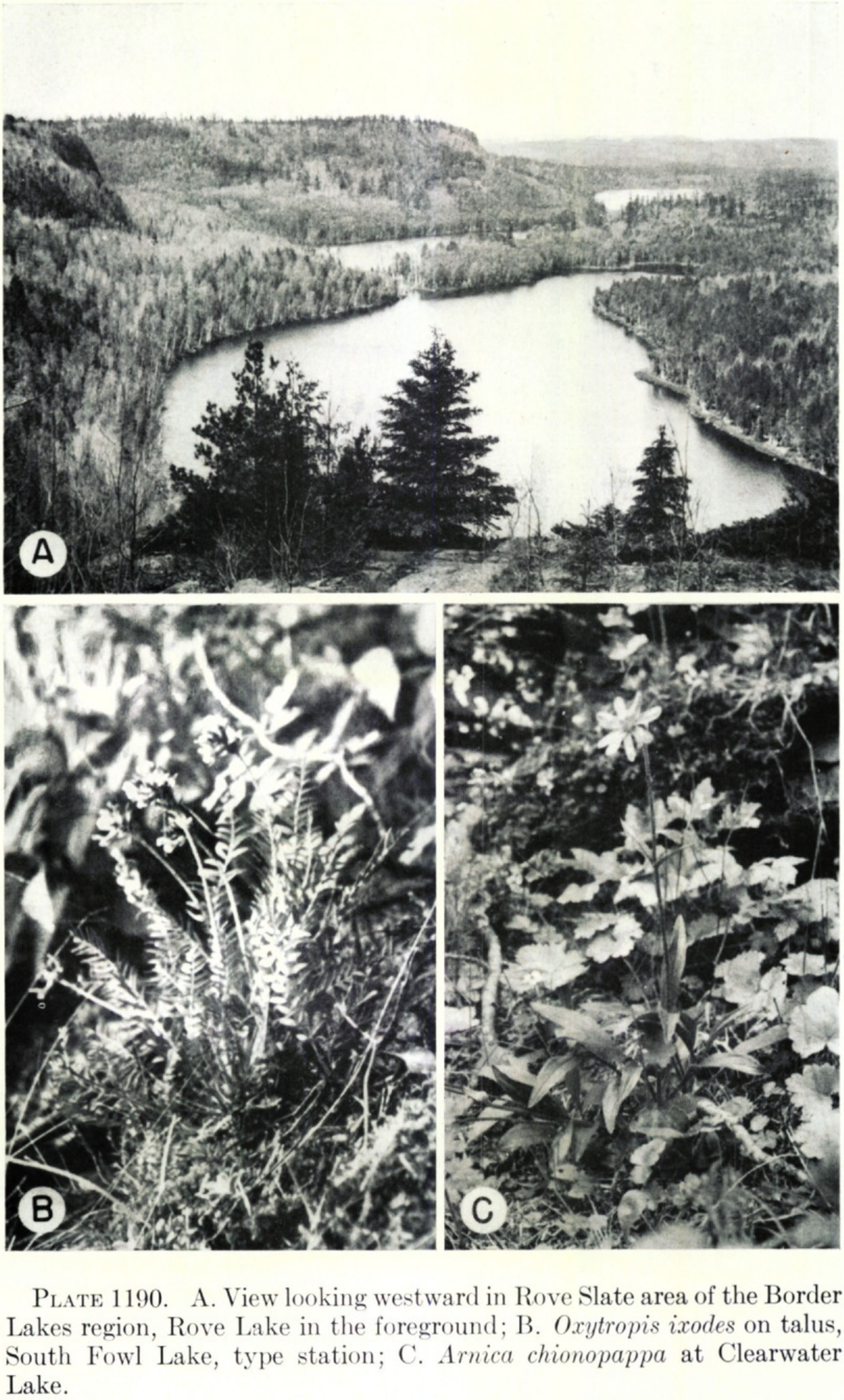

PLATE 1190. A. View looking westward in Rove Slate area of the Border Lakes region, Rove Lake in the foreground; B. *Oxytropis ixodes* on talus, South Fowl Lake, type station; C. *Arnica chionopappa* at Clearwater Lake.

PLATE 1191. Lake Superior shore types in the Susie Islands; high rocky shore in foreground, low rocky point in background.

Relatively bare rock surfaces characterize much of the lake shore (Plate 1191), becoming fairly extensive on the wave-washed points.

Residual material other than that of glacial origin is limited in extent. However, some phases of the Duluth gabbro, in areas only recently exposed by the retreating waters of Lake Duluth, (Fig. 3D) have already developed areas of raw regolith, or disintegrated mantle rock, due to post-glacial weathering.

Glacial deposits cover great areas of the county. These take the form of outwash, ground moraines and lake plains. They vary from the finer sediments of the lacustrine clays formed under the waters of Lake Duluth and its successors to coarse boulder trains on parts of the upland.

2. Geological Features

a. The Bedrock Geology. The bedrock geology of the county has been discussed at considerable length in a number of publications by members of the Department of Geology of the University of Minnesota. Publications by Grout and Schwartz (1933 and 1939) and by Gruner (1941) form the basis for the following summary.

In fig. 2, C and D, there are summarized the salient features of the structural geology of the county. In the northwesternmost part of the county there are exposed the Saganaga granites and Ely greenstones of Archean age which are overlain by agglomerates and conglomerates of the Knife Lake series of Algonkian age. These rocks are overlain unconformably by the Gunflint iron formation and the Rove slates, which are exposed in the rest of the northern third of the county. The Rove slates are overlain and intruded by flows and intrusives of the Keweenawan series, which extend eastward to Lake Superior. The presumed historical sequence of events is graphically described by Gruner (1941, pp. 1638–40) in his paper on the Knife Lake series.

The importance of the bedrock geology lies both in its influence on the topography and on the till and soils derived from it.

Zumberge (1952) devotes considerable attention in his study of Minnesota lakes to the bedrock control of topography in the Border Lakes region. He emphasizes the fact that the relative absence of glacial deposition in the area permits a full expression of the interplay between glacial erosion and bedrock geology. In the Saganaga granite area (Fig. 2 C) many of the lakes (Fig. 1) have linear segments related to the rock joints. In the Duluth gabbro the lakes tend to be elongate because of the differential erosion of the banded gabbro. In the Rove slate area the east-west valleys are in troughs eroded in the slate exposed between successive layers of diabase (Fig. 2B). Here, unlike the rest of the county, there are sharp ridges between the lakes. The edges of the diabase caps over the Rove slates are responsible for these ridges, which slope gently to the south, but have precipitous northern faces rising from 200–400 feet above the lakes. The abruptness of the faces of these cliffs is maintained by the rapid weathering of the slate underlying the diabase. Slate shards form the upper part of many of the talus slopes while the coarse diabase blocks falling from the brows of the cliffs tend to accumulate at the bottoms of the talus slopes. Phytogeographically, these cliffs are significant because their active weathering and the moving material of the talus prevents the establishment of forest until late in the physiographic history of the cliffs.

The relation of the bedrock geology to the nature of the drift and to the soils of the county in its broad aspects is fairly clear. At one extreme lie the Saganaga granites which produce an acid medium for growth, and one which seems low in availability of the nutrients required by many plants; at the other extreme lie the Rove slates which tend toward the calcic, as do some phases of the gabbro and diabase, favoring the growth of calcicoles.

b. Glacial Geology.[4] The riddle of the re-population of Cook County by plants is intimately inter-related with the recent glacial history of the county. Two questions arise, one, when did the surface of Cook County first become available for plant immigrants, the other, what was the nature of the terrain and presumed climate which greeted the newcomers? For our purposes it is desirable to try to reconstruct the sequence of events in northeastern Minnesota generally as the background

[4] The junior author is deeply indebted to Dr. R. P. Sharp for his generosity in making available as yet unpublished information (Sharp, in prep.) derived from his field work in Cook County during the summers of 1946–47. Most of the material in this section is adapted from his manuscript. Dr. H. E. Wright, Jr. has contributed much unpublished material from his work (Wright, in prep.) on the Superior Lobe. Neither Dr. Sharp nor Dr. Wright is responsible for possible error of statement here.

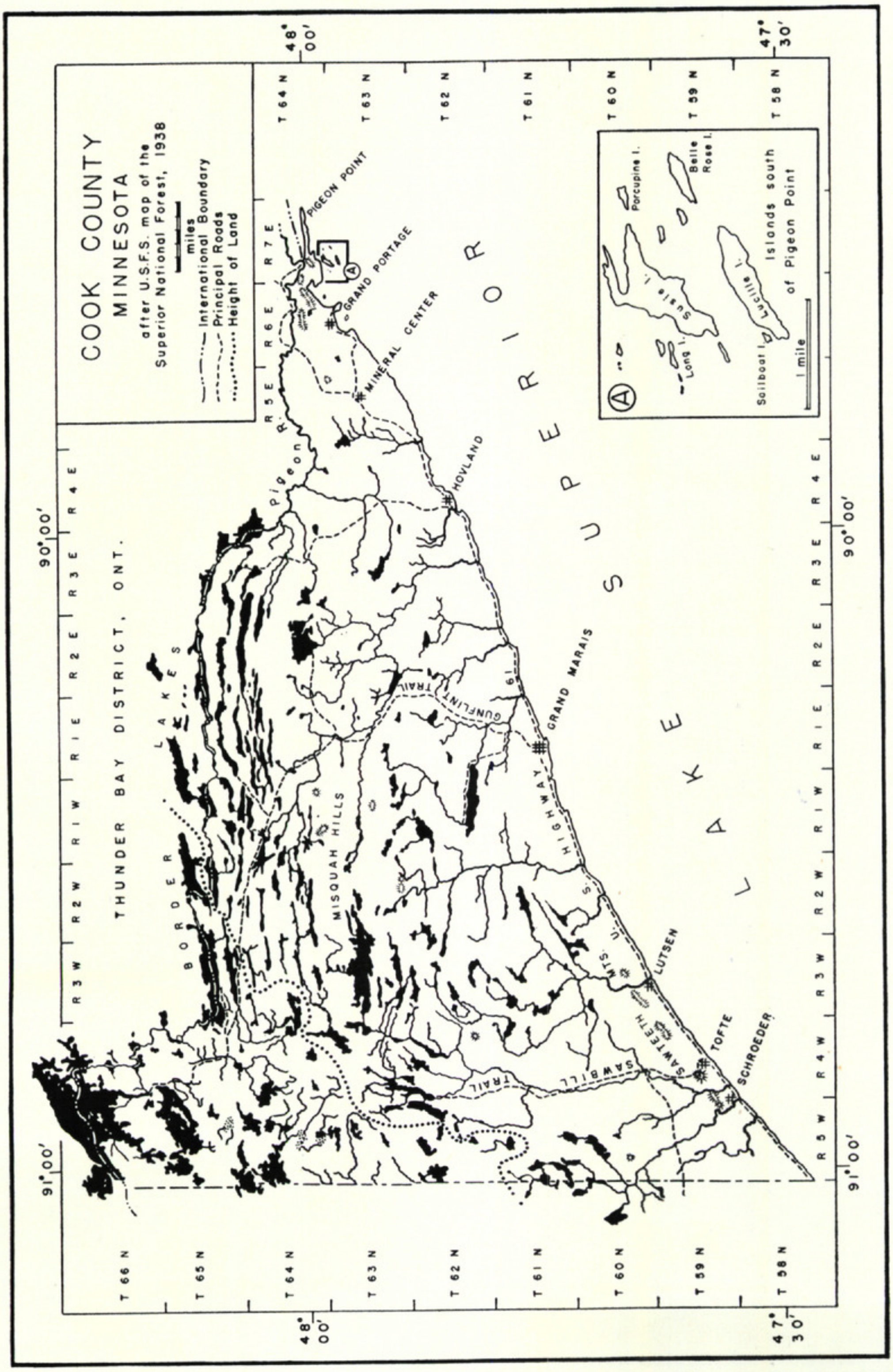

FIG. 1. Outline Map of Cook County; Inset A shows the Susie Islands in fuller detail.

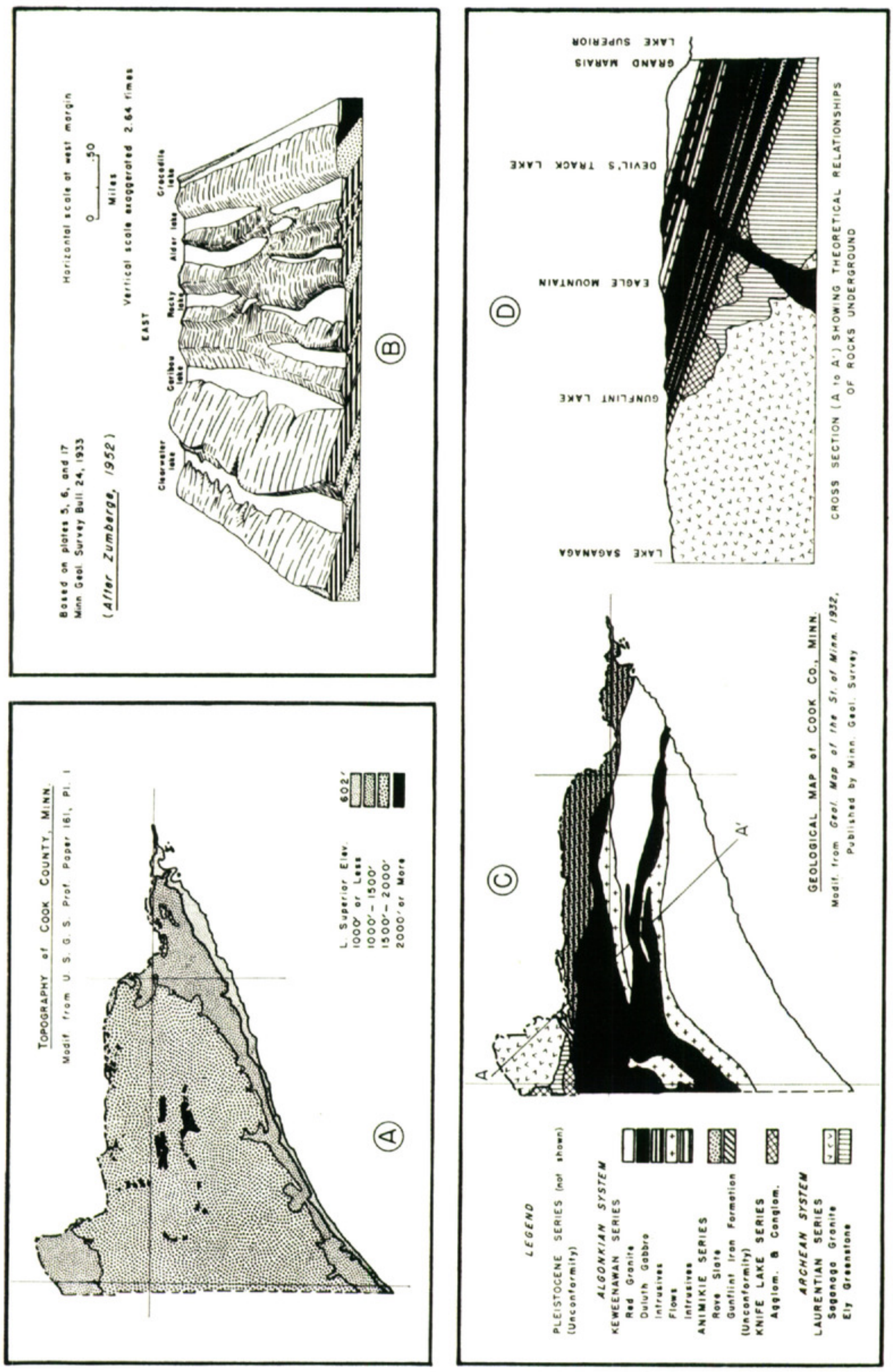

Fig. 2. Topography and Geology of Cook County. A. Topography; B. Block diagram to illustrate relation between geology and topography in the Rove Slate area; C. Geological formations of Cook County; D. Hypothetical section along line A-A′ in C.

against which to view the floristic history of Cook County. It is immaterial in the present study whether we think in terms of a single great Laurentide ice-sheet with Labradorian, Keewatin, and other centers of outward flow (Johnston, 1935; Flint, 1943), or whether we accept the long current concept of relative independence of these centers. We are specifically concerned with the ebb and flow of the Pleistocene ice within a restricted area, the Arrowhead region of Minnesota.

The scanty drift of our area seems to provide no evidence for glaciation before the Wisconsin, although Leverett (1932, p. 20) does not entirely preclude the possibility. Glacial erosion was dominant over deposition, and older glacial deposits were probably all removed during the Cary invasion. All the drift exposed on the surface is either Cary or younger in age, for it is marked by an abundance of undrained depressions, a feature not common on Tazewell or older drifts.

Cary glaciation in Cook County was accomplished by the Rainy Lobe (Elftman, 1898; Sharp, in prep.), which advanced to the south or southwest across the country. Current investigations by Wright (in prep.) suggest that the Superior Lobe was also active in Cary time, perhaps slightly later than the Rainy Lobe, and rose up from the Superior basin onto the highland rim of southern Cook County. He believes that the Superior Lobe extended west and south from the head of Lake Superior, perhaps with some Rainy Lobe ice, to reach south-central Minnesota as the Minneapolis lobe of Cooper (1935). The sketch (Fig. 3A) suggests by arrows the direction of movement of Cary ice in northeastern Minnesota.

The part of Cook County not covered subsequently by the Mankato Superior Lobe or its melt-water displays a multitude of evidences of the activity of the Cary Rainy Lobe. Ice-scoured rock outcrops with polish or striae, grooves or chatter marks, and larger features such as roches moutonées, excavated rock basins and hills, etc., are major evidences of its activity. In association with these there are great areas of a poorly consolidated brown till perhaps an average of 15 feet thick and largely (up to 90%) derived from the underlying bedrock. Glacifluvial debris, largely sand and gravel, produce in much of this area swells and swales, knobs and kettles and short ridges with a relief of about 20 to 50 feet. These Sharp attributes to deposits accumulated upon, around and perhaps under masses of stagnant ice with debris swept onto them due to the wastage of the main ice mass of the Rainy Lobe. There are also at least sixteen clearly defined eskers 20 to 90 feet in height which add diversity to the landscape and bear testimony to glacifluvial deposition, probably in this case by glacial streams in sub-glacial tunnels. Drumlinoid ridges occur in the broad lowland along the Cross River. In the eastern part of Cook County there are brown silty clays formed in the valley of the Pigeon River; Sharp refers these sediments to proglacial Lake Pigeon which was formed by Rainy Lobe melt-water backing up against the body of the Superior Lobe which makes them early Mankato deposits.

The Two Creeks Interval is indicated in Fig. 3 because of its importance in dating events in the late Wisconsin. The Superior basin was occupied by a lake in which were deposited the red clays referred to below. The surface of Cook County during this phase was presumably free of ice, at least in large part. How long before the dated part of the Two Creeks Interval (about 11,000 years at Two Creeks, *cf.* Flint and Deevey, 1951) Cook County was ice-free is an open question, but it may well have approximated a total of 20,000 years to the present.

It appears that the Cary Rainy Lobe had largely receded from Cook County before the final advance of the Superior Lobe in Mankato time (Fig. 3B). Evidence for this conclusion is the deposition by the Superior Lobe of its characteristic red clay till over areas formerly occupied by the Rainy Lobe. It is very probable that the time interval between the two was relatively short. Cooper (1935) presents evidence from somewhat to the south of our area that blocks of late Cary ice may have been buried by Mankato outwash. The interval between these episodes has been arbitrarily set at 2500 years by Antevs (1945), but this may be much too long, judging both by Cooper's observations and by the relative magnitude of time intervals in general as determined in recent radiocarbon studies (Flint and Deevey, 1951).

With the Rainy Lobe to the north, the Mankato Superior Lobe invaded our area from the east by way of the basin of present Lake Superior (Fig. 3B). Proglacial lakes no doubt were im-

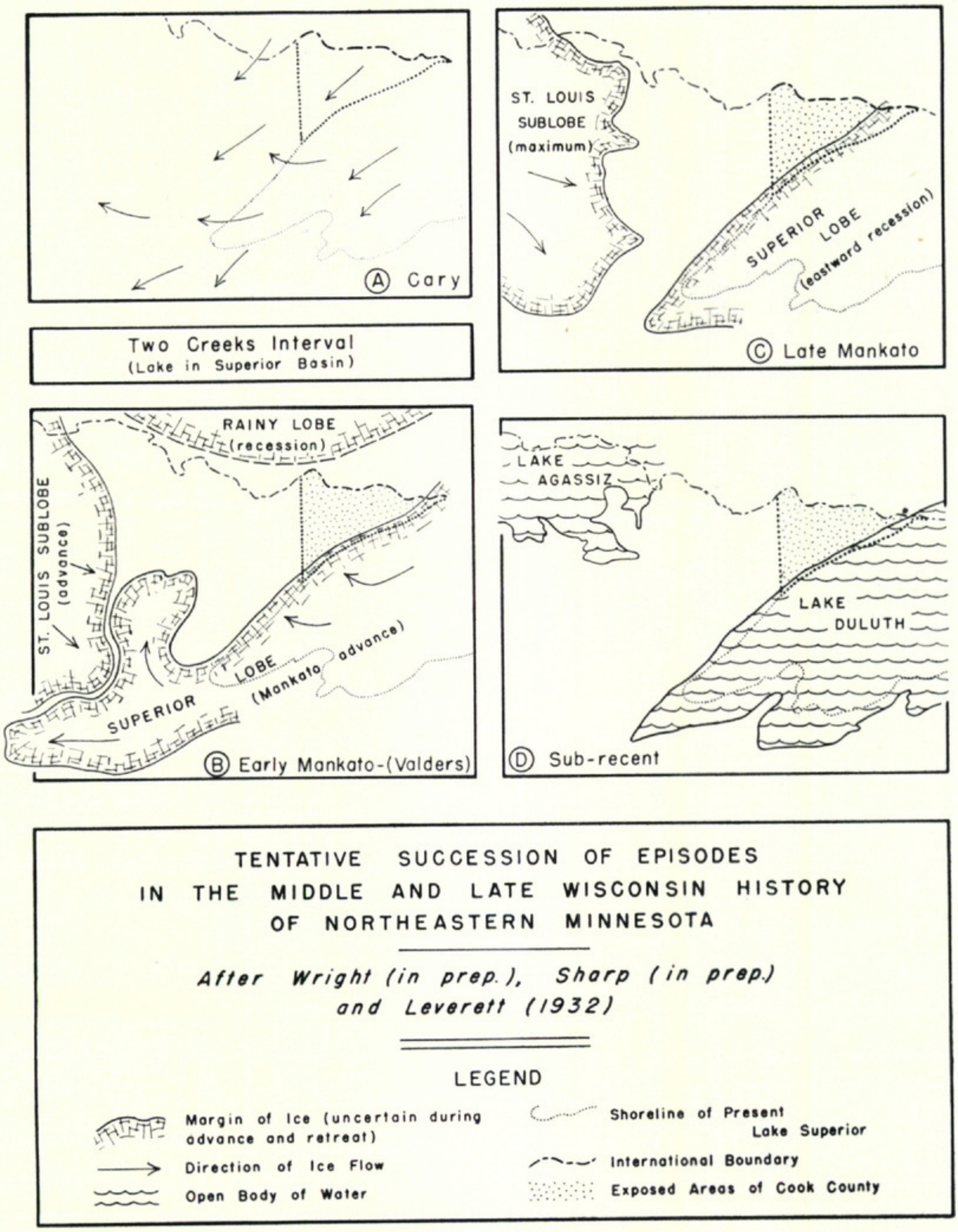

Fig. 3. Tentative Succession of Episodes in the Middle and Late Wisconsin History of northeastern Minnesota.

pounded by the advancing ice, but their red clay bottom deposits were probably ploughed up to form part of the till of the advancing ice. Those most readily recognizable in Cook County are all above the maximum elevation of the uppermost strand line of Lake Duluth (about 1270 feet in Cook County). One group of these proglacial lakes of Mankato time occurred north of the Sawteeth Mountains in the valleys of the Poplar, Onion and Temperance Rivers; another proglacial lake occupied the Mineral Center area; and a very large one named Lake Omimi by Elftman (1898) occupied much the same area in the Pigeon River drainage as Sharp's proglacial lake of Cary time. The beds of these proglacial lakes of the Superior Lobe are characterized by their red and locally calcareous clays which overlie the brown deposits left by the Rainy Lobe.

The retreat of the Superior Lobe (Fig. 3C) left a red clay till sheet 5 to 15 feet thick roughly paralleling the present shore of Lake Superior 3 to 5.5 miles inland in Cook County, the margin of the lobe having attained an elevation of about 1450 feet near Grand Marais. The till is uncomplicated by any appreciable glacifluvial deposits, and has modified but little the topography of the region where it occurs.

A series of major glacial lakes, beginning with Lake Duluth (Fig. 3D), filled the Lake Superior basin as it was vacated by the waning Superior Lobe. Their waters reworked the red clay till of the Superior Lobe from the 1270 foot level downward and in some cases also permitted the deposition of a thin veneer of sandy gravels over the red clays. Well-defined strand lines, including wave-cut cliffs and raised gravelly beaches of the various glacial lakes are outstanding features of the shore region of present Lake Superior, although there is no local evidence for a stage recognized by Stanley (1938) as lower than the present one.

As the Superior Lobe waned eastward there was an ice invasion into northeastern Minnesota from the northwest—the St. Louis sublobe of the Des Moines Lobe (Fig. 3B & C). The recession of the Superior Lobe began before the culmination of the Des Moines. It is presumed that the maximum eastward limit of the St. Louis sublobe was reached after the retreat of the Superior Lobe had begun because of the absence, for instance, of interlobate till deposits which would indicate actual contact between the Superior Lobe and the encroaching St. Louis sublobe. Furthermore, Leverett (1932) states that morainal material produced by the Superior Lobe is overlain by drift from the St. Louis sublobe. The St. Louis sublobe achieved its maximum advance to the east in St. Louis County—still leaving

Cook County and its western neighbor, Lake County, free of ice (Fig. 3C). Upon the retreat of the parent Des Moines Lobe, Lake Agassiz extended into the northwestern part of the Arrowhead region (Fig. 3D). From that time on the Arrowhead has been free of continental ice.

c. Soils. The general character of the soils of the county has been determined to a large extent by its glacial history and its bedrock geology. These have been described in the two preceding sections.

Two major soil associations are recognized in the county (McMiller, 1947); one is the Ontonagon, the other the Milaca-Cloquet soils group.

The Ontonagon is the local representative of the *Brown-Forest* soil group and occupies the portions of the county formerly covered by Lake Duluth (Sharp, in prep.). It is a gray to light grayish brown clay loam derived from the red lake clays and the Superior red clay of the original parent material. There is a relatively high content of bases which seems to retard the process of podzolization. By implication, then, it is conceded to be an immature soil, a view in keeping with its known history in Cook County.

The Milaca-Cloquet is the local representative of the *Brown-Podzolic* soil group and occupies that portion of the county in which the present surface formations are the result of the activity of the Rainy Lobe. It is derived from the brown sandy tills. Nygard, McMiller and Hole (1952) in their discussion of brown-podzolic soils comment on the occasional occurrence of "double profiles" (a repetition of the profile), which Wright (*in litt.* Oct. 5, 1951) has suggested is a record of climatic and vegetational change.

Little, if any, information on the very extensive peat soils is available.

In contrast to these widely distributed Cook County soils, there are "soils" of very limited occurrence today which are of marked phytogeographical importance. These occur at the upper margins of the talus slopes and on ledges of the high cliffs of the Rove slate area, as well as on recently exposed surfaces of some phases of the diabase trap which weather quickly. All of these soils have in common the characteristic of extreme newness, a gravelly to fine texture, and of being subject to disturbance due to freezing and thawing. Quite naturally they partake of the character of the parent rock. When this is slate or a basic phase of the diabase the raw gravelly soil, if moist, often forms an excellent substratum for the growth of the rarities of the region. The absence of root competition or shading due to forest trees in the limited areas where these soils are formed further favors these plants.

On the other hand the original glacial soils of the county, even when they were somewhat calcareous, are becoming progressively more acid as the humus produced under the widely dispersed coniferous forest continues to accumulate. Added to this is the leaching of the calcium carbonate and the decomposition of calcium-bearing silicates followed by removal in solution of their calcium. This is very markedly the case in portions of the county in which the underlying rock is fundamentally acid, such as the Saganaga granites. Thus the extent of the substratum suitable for the growth of calcicoles is becoming progressively more limited. An example of this is to be found on the talus slopes in the Rove slate area (Plate 1190A). The talus slopes below the smaller cliffs have by now become stabilized and are covered by the encroaching and ubiquitous coniferous forest. It is only the tallest cliffs whose taluses have not yet been stabilized, and which therefore have not yet been invaded by the forest. Here are still to be found the basic gravels in a narrow strip along the top of the taluses and on ledges where the rarities survive.

On the shore of Lake Superior the analogue of the localized gravels of the back country is to be found in the new rock surfaces which are being exposed as the beach line drops with the passage of time (Plate 1191). On the ledges of the exposed shore cliffs and in the cracks and crevices of the rock points contemporary weathering is producing mantle rock derived directly from the underlying bedrock. The forest has often not yet occupied these areas, so that again rarities have the opportunity of surviving in these limited and precarious ecological niches.

3. Climate

The contemporary climate of Cook County has been summarized by Pursell (*in* Leverett and Sardeson, 1917) and more recently by Hovde (1941). The data presented below are largely taken from the latter. Observations in the county are primarily limited to the station at Grand Marais.

The climate of the county may be characterized as cool temperate. Along the shores of Lake Superior it is strongly conditioned by this vast cold mass of water. According to Pursell the mean annual temperature of the county varies from 36° to 38° F. in contrast to an average of about 45° F. in the hot southeastern part of the state.

The mean temperature in January ranges from 8° F. along the Lake Superior shore to 14° F. inland, and has reached a minimum of − 34° F. during the winter; in July it ranges from 60° F. at the east to 62° F. in the west, and a summer maximum of 100° F. has been recorded.

The frost-free season is approximately 120 days in length as contrasted with one of 150–160 days in the southernmost part of the state. The last killing frost in the spring occurs about May 25 in the southern part of the county and is about 5 days later in the northern part of the county; the first in the fall is about September 15 in the southern part of the county and about 10 days later inland from Lake Superior.

Annual precipitation is between 24.7 and 31.5 inches, of which about 18 inches is during the warmer months. Information on the depth of winter snow, so important in its bearing on depth of soil frost and plant cover, seems to be unavailable.

There is a gradient in summer climate even within the rather limited area of the county. The region along the immediate shore of Lake Superior is colder and often foggy in summer, while the "back country" on the plateau extending to the Border Lakes is warmer and the skies clearer.

Information concerning microclimates is completely lacking although it would be of great interest to have this, especially because of its possible bearing on the localized occurrences of the rarities. Perhaps the most significant testimony, short of actual instrumental observations, is that the microclimates in restricted ecological niches permit the growth and reproduction of a limited number of species with subarctic or other geographic affinities.

The fluctuations in sub-recent climates are of tremendous significance in view of the diverse floristic components of the county. In contrast to the earlier experience of the junior author (Abbe, 1936) it is no longer necessary to plead the case for a "xerothermic" period or a "climatic optimum" or thermal maximum (Flint and Deevey, 1951) during post-glacial time. The evidence for considerable variation in post-glacial climates is clear both for Europe and America, and has been admirably summarized and evaluated by Deevey (1949). Today the major problems are, (1) the probable sequence of climates in any particular locality (*cf.* Deevey, 1949, Table 7) and, (2) the probable duration of each. The former is far more significant phytogeographically than the latter, especially as it concerns "late glacial" time. Certainly the duration of the climatic phases should not be dismissed summarily from consideration, but in view of the speed with which species are dispersed, especially if a great reservoir of individuals is immediately adjacent to a region about to be invaded, time seems to become limiting only under exceptional circumstances.

Flint and Deevey (1951) summarize radiocarbon data which permit the conclusion that the Mankato maximum in the Two Creeks (Wisc.) area occurred about 11,000 years ago. This provides an approximate base for determining the date of the final opening up of the Arrowhead region for permanent plant occupation; the departure of ice during the Cary would be our critical date—it would antedate 11,000 years appreciably.

The first climatic phase in our glaciated areas which is significant to the phytogeographer is that which existed at or near the ice margin. Deevey, by 1949, was able to cite only one case, and that for Maine, in which pollen analytical studies provide useful evidence concerning the plants of the periglacial zone. Apparently in Maine "tundra" species existed near the ice margin. Supporting evidence from the middle west is provided by Sharp's (1942) report of involution layers in glacifluvial formations in the upper Illinois valley. Their presence leads Sharp to conclude that periglacial or arctic conditions existed at a distance of 30 to 50 miles beyond the border of late Cary ice. Certainly, as Deevey (1949) explains, more evidence from North America is badly needed; but by analogy with the wealth of information available in Europe it may be expected that subsequent research will demonstrate the transitory presence of pioneer, cold tolerant, short season species in areas that were immediately adjacent to the ice. Their presence would not necessarily constitute evidence for the existence of a tundra climax at such localities.

Following the pioneers in depositional sequence are the plants so well known on palynological grounds from the upper Middle West (Minn. to Ind.) and summarized by Deevey (1949, Table 7) as follows. Zone A, characterized by spruce and fir, which are taken to indicate a cool climate; Zone B, with pine indicating a warmer, dry climate; Zone C1, with pine, oak and elm in Minnesota and Wisconsin followed by Zone C2, with pine declining in Minnesota and Wisconsin indicating a warm, dry climate; Zone C3, with spruce returning at some localities in Wisconsin and Minnesota suggesting a trend toward a cooler, moister climate.

Too specific an application in Cook County of the above generalizations is unwarranted, the more so because no pollen analytical data have been obtained there. It seems reasonable to assume that as the Cary ice disappeared from the Arrowhead, something over 11,000 years ago, there was a periglacial climate which could be tolerated by pioneer species capable of quickly invading the new terrain. Many of these were arctic and tundra species whose descendants are still present in the area. This pioneer conglomerate—one hardly dares call it a well-defined community—was probably promptly infiltrated by willows, aspens, balsam poplar and northern conifer forest species as quickly as they could migrate in from adjacent seed sources. No general moderation of climate would be necessary for such a succession of events, although at least the microclimates must have changed. However the incursion of hardwoods and the subsequent return of the conifers is surely to be related to the thermal maximum of 3,000 (to perhaps 6,000) years ago (Flint and Deevey, 1951).

A guess as to the magnitude of the climatic change from the thermal maximum to the present may be based on a comparison of Cook County with the present "Big Woods" in the south central part of the state (*cf.* Braun, 1950). That this comparison is relevant is supported by the presence today of relic stands of sugar maple in Cook County. In the "Big Woods" the growing season is 140 to 150 days, as contrasted with about 120 days in Cook County; the mean July temperature in the "Big Woods" area is 70–72° F., while it is about 60–62° F. in Cook County (Hovde, 1941). Thus during the thermal maximum, perhaps 3,000 years ago, the growing season in Cook County might well have been 20 to 30 days longer and the mean July temperature 10° F. higher. Such conjectures must be looked upon with marked skepticism until further evidence is brought to bear upon them. Biological evidence would appear to be most productive of results here, but care should be taken to avoid organisms with very brief life spans so that the possibility of very rapid selection is excluded. From this point of view long-lived trees like the sugar maple seem, superficially at least, to be very favorable for such a purpose.

4. Summary of Environmental Conditions in Cook County

The county is in the western part of the Laurentian Upland and possesses the greatest range in elevations in the state—from 602 ft. above sea level along the Lake Superior shore to 2230 ft. for the Misquah Hills inland. There is an abrupt rise from the shores of the lake to the Sawteeth Mountains at the southern edge of the rolling upland, which itself averages about 1500 ft. above the sea level.

Bedrock control of topography is marked. The northwestern part of the county, beyond the height of land is primarily occupied by Archean rocks, the Saganaga granites and Ely greenstone. Here the drainage is northward into the Hudson Bay system, and the lakes are more or less rounded in outline. The rest of the northern part of the county is the area of the Gunflint iron formation and the phytogeographically important Rove slates, both being older phases of the Algonkian system. Keweenawan flows and intrusives extend into this area, being responsible along with the interbedded slates for the development of a pronounced cuesta type of topography. East-west valleys are strongly developed, and the deep lakes in them are set off on their southern sides by large, north-facing cliffs, many of which have active talus slopes. The rest of the county is occupied by more recent phases of the Algonkian, red granite, Duluth gabbro, and extensive developments of Keweenawan intrusives and flows. Topographically the region is rolling, its lakes tending to follow the grain of the country, but less limited in form than are those of the Rove slate area. In general the rivers flow southward, forming miniature canyons in their final descent to Lake Superior.

At least 25% of the surface of the county is occupied by lakes and muskegs, the balance being glacial materials except for extensive exposures of ice-scoured and bare rock. The glacial material in the region not subsequently covered by the Mankato Superior Lobe is largely a poorly consolidated brown till reflecting the character of the underlying bedrock; glacifluvial debris and other localized manifestations of the activity of the Cary Rainy Lobe are also present. In the region covered by the Mankato Superior Lobe and the bodies of water impounded by it, the surface material is a characteristic red clay till and red lake clay.

The general sequence of events from the maximum of the Rainy Lobe to the present seems fairly clear. At its maximum the Cary Rainy Lobe completely covered Cook County. The Rainy Lobe retreated northward across the Arrowhead and the Superior basin was filled by a lake—this was the Two Creeks Interval more or less reliably dated on C_{14} evidence as about 11,000 years ago. This was followed by an invasion of the Superior basin by the Mankato Superior Lobe; this may have been a reinvasion. Contemporaneously there may have been a slight southward readvance of the Rainy Lobe, but not far enough south to meet the Superior Lobe. There also began an advance from the northwest—the St. Louis sublobe. The Superior Lobe then began its final eastward retreat, and the Rainy Lobe its northward retreat, while the St. Louis sublobe attained its maximum southeastward extension. The continued eastward waning of the Superior Lobe in the Superior basin dammed the meltwaters there to produce a series of glacial lakes, one of which was Lake Duluth; similarly the parent body of the Rainy Lobe of the St. Louis sublobe had retreated northward into the Hudson Bay basin and acted as a dam which impounded Lake Agassiz. The final disappearance of ice in the Superior and Hudson Bay basins allowed Lake Agassiz and Lake Duluth to shrink to the limits of the lesser contemporary bodies of water now in their respective basins. Thus at least from late Cary time something more than 11,000 years ago when the Rainy Lobe retreated north across Cook County, this area has been available for plant immigration and occupation. The direction of migration was probably northeastward, westward, and southwestward from areas of vegetation not destroyed by Cary and Mankato ice.

The mineral soils of the county strongly reflect its bedrock geology and its glacial history. The region formerly occupied by Lake Duluth has clay loams belonging to the *Brown-Forest* group, while the rest of the county has soils belonging to the *Brown-Podzolic* group. Double profiles occur in the latter, which may indicate broad climatic fluctuations in the area. Very limited "soils," or more properly, finely comminuted rock material of contemporary origin, occur on the exposed rocks and cliff bases in the county; these are of great phytogeographic interest because they harbor certain of the rarities of the county. Whatever the origin of the soil there is a gradual tendency toward leaching out of the bases, so that habitats suitable for calcicoles are becoming progressively more limited except for the current production of fine gravel due to weathering of exposed rock.

The contemporary climate is cool temperate; the growing season is relatively short (about 120 days); precipitation is abundant both in summer and winter, with a plentiful snow cover in the winter. Judging by the presence of relic stands of sugar maple, the climate was probably somewhat milder during the thermal maximum perhaps 3 to 6,000 years ago. The extent of this "mildness" may be judged from the greater length of the growing season by 20 to 30 days, and a mean July temperature some 10° F. warmer in the "Big Woods" part of the state where the sugar maple thrives today. This thermal maximum marked the culmination of a period of climatic amelioration which started with a frigid periglacial tundra climate over 11,000 years ago.

5. General Features of the Flora and Vegetation

The immediate impression that is given by the plant cover of Cook County is one of a boreal wilderness uncomplicated by extensive agriculture, and but slightly modified by the tourist trade along the roads. Nevertheless, fires following heavy and destructive lumbering shortly after the turn of the century

PLATE 1192. Center of Lucille Island (Susie Islands); opening in dense spruce forest, Dr. F. K. Butters in foreground, Mrs. L. B. Abbe in middle background.

(Smith and Moyle, 1944) added to the effects of earlier fires set by mineral prospectors (Winchell, 1879; Hall, 1880) led to an extensive development of "brush"; only recently has much of this returned to thrifty second-growth woods. While these man-made catastrophes have left their imprint on great areas, there still remain limited patches of nearly virgin forest in the more inaccessible parts of the county.

A detailed ecological analysis of the county still remains to be made. Fortunately Cooper's (1913) classic account of the development of the climax forest of near-by Isle Royale is available. One major feature of the flora in Cook County which is not treated in Cooper's study is what may be termed the talus slope succession and another is the sugarbush, both of which are of great phytogeographic significance. Otherwise the application of Cooper's observations becomes a problem in the redistribution of emphasis; especially is this the case with the secondary successions which on Isle Royale are burn successions of limited extent, but in Cook County constitute a very widespread phenomenon.

Primary successions:—Cooper finds these falling into two series on Isle Royale, one xerarch, the other hydrarch. His xerarch successions along the shore are in a large part initiated on the well-drained rock surfaces, in the crevices of these shore rocks, and in the rock pools. The pioneers are crustose lichens and mosses on the rock surfaces, and *Potentilla tridentata, Trisetum spicatum, Aster ptarmicoides, Campanula rotundifolia,* etc., in the rock crevices, and *Scirpus cespitosus, Potentilla tridentata, Vaccinium angustifolium,* and mosses by the rock pools. Each series is followed by a sequence of other species—other lichens in the case of the rock surfaces, shrubs such as *Vaccinium uliginosum, V. angustifolium, Juniperus horizontalis, J. communis* var. *depressa, Arctostaphylos Uva-ursi* in the crevices, and *Vaccinium uliginosum, V. angustifolium, Andromeda glaucophylla* and *Calamagrostis canadensis* by the rock pools. These subsuccessions ultimately coalesce into the heath mat in the formation of which the crevice species are the active agents. The mesophytic climax forest (*Abies balsamea, Betula papyrifera sens. lat.,* and *Picea glauca*) either invades the heath mat directly, or the xerophytic forest (*Pinus Banksiana* and *Picea mariana*) acts as an intermediary to the establishment of the mesophytic climax. The xerarch successions may also be initiated on the beaches which are of limited extent and but sparsely occupied by such species as *Equisetum arvense*, *Epilobium angustifolium*, *Deschampsia caespitosa*, etc., which are followed by such shrubs as *Alnus crispa*, *Cornus stolonifera* and *Salix* spp., which finally and often abruptly give way to the mesophytic climax forest.

Cooper's rock shore and beach successions are described in great detail and apply very aptly to similar Cook County conditions as these now exist along the shore of Lake Superior. Only in one detail does the junior author find his observations subject to criticism—this is in Cooper's brief discussion of a "gull" island with its curious admixture of shore and forest species. Such islands also occur on the North Shore of Lake Superior, and the junior author has noted them on the North Shore of the Gulf of St. Lawrence, on the coast of Labrador, and on Hudson Bay. These "grassy" islands are sporadic in occurrence, other islands of similar size failing to be occupied by waterfowl and then exhibiting floristic conditions which may be considered essentially normal. I cannot therefore agree with the suggestion hazarded by Cooper that the "grassy" islands may have the kind of vegetation which first occupied the islands of Lake Superior and its predecessors as these islands emerged and became available for plant occupation. I am willing to recognize the probability that gulls and other waterfowl occupied occasional ones of the islands which slowly emerged, and that the floras of these islands would resemble the one described by Cooper, but I am of the opinion that the floras of islands equally small and not so occupied would follow Cooper's rock shore and beach succession.

In addition to the xerarch successions, Cooper describes two types of hydrarch succession. One is the bog succession which is initiated by aquatics (*Ranunculus trichophyllus*, *Potamogeton perfoliatus*, *Carex* spp.) followed by a sedge mat which may be followed either by bog shrubs (*Chamaedaphne calyculata*, *Andromeda glaucophylla*, *Alnus rugosa* var. *americana*) giving way directly to bog forest (*Larix laricina*, *Thuja occidentalis*) or first passing through a *Ledum groenlandicum*-*Sphagnum* phase before a bog forest of *Larix laricina* and *Picea mariana* becomes established. In either event the bog forest is ultimately succeeded by the mesophytic climax forest. Again Cooper's observations are eminently applicable to the great areas of bog in Cook County, whether on the upland or within the shore area.

The second of Cooper's hydrarch successions is that of the delta swamp succession in which an initial phase of aquatics is followed by the sedge mat as in the bog succession. At this point there may be a shift to the bog shrub association which proceeds through the bog forest to the climax forest. However he observes that in general the sedge mat is invaded by grasses, notably *Calamagrostis canadensis*, followed by shrubs (*Myrica Gale*, *Alnus rugosa* var. *americana*), and then by the swamp forest (*Thuja occidentalis*, *Larix laricina*, *Fraxinus nigra*) which again culminates in the climax forest. In Cook County the areas suitable to the development of this succession are relatively limited as compared with the bog succession, but are nevertheless fairly numerous both on the upland and along the shore of Lake Superior.

Secondary successions:—On Isle Royale Cooper describes two burn successions each of which follows fire in the climax forest. In one the coniferous element of the climax is destroyed but the humus is little harmed. The surviving birches sprout from the stump, *Epilobium angustifolium*, *Anaphalis margaritacea*, seedling birches and aspens come in, and finally the conifers return, re-establishing the climax forest. The second type of burn succession follows a more drastic type of fire in which the humus is destroyed and the bare rock is exposed. The return of the climax follows essentially the rock shore succession. In Cook County the picture is undoubtedly far more complex than this in view of the burning and re-burning which has occurred in various stages of the variety of possible successions. Vast areas of the county fall in this category and await detailed study.

Another type of secondary succession which the situation on Isle Royale presumably does not cover is initiated by the man-made destruction of the original plant cover along roadsides, barrow pits, clearings about buildings, and the naturally occurring cut-banks along streams and rivers, and the local effects of major rock falls from cliff faces onto the subjacent talus slopes already in the various stages of the talus succession.

One of the most significant associations on Isle Royale, that dominated by *Acer saccharum*, Cooper could not study, but recognizes the fact that "southward it is probably able to supersede the conifers and birch." The importance of this association in Cook County cannot be overlooked, and naturally the question arises as to why it has not "superseded" the conifers there also.

The three major types of forest which the writers have noted in Cook County are:—*a.* the Jack-pine barrens of the northwestern part of the county; *b.* the mixed conifer-hardwood forest occupying most of the upland and slopes along the shores of Lake Superior; and *c.* the localized groves of "sugar bush" occurring along the southern shoulder of the upland.

a. Jack-pine barrens.—As indicated by their name, these are characterized by *Pinus Banksiana.* They occur in the northwestern part of the county where the underlying rock consists predominantly of the acid Archean granites and where the drift mantle is itself acid like the underlying granite. Rapid drainage of the soil and its low nutrient supplying power also are major factors. Undergrowth is characteristically sparse, some of its species being *Vaccinium angustifolium, Rosa acicularis* (*sens. lat.*), *Chimaphila umbellata* var. *cisatlantica,* etc.

Extensive *Betula pumila-Ledum-Chamaedaphne* bogs occur in the shallow rock basins of this part of the county. Along with *Betula pumila* var. *glandulifera, Ledum groenlandicum,* and *Chamaedaphne calyculata* are their familiar companions in this type of bog, such as *Andromeda glaucophylla, Carex tenuiflora, Salix pedicellaris* var. *hypoglauca, Solidago uliginosa, Sphagnum* spp., *Vaccinium Oxycoccos,* etc., etc. Essentially similar bogs occur here and there throughout the mixed conifer-hardwood forest area, although, oddly enough, *Betula pumila* var. *glandulifera* is characteristically absent from them.

The flora of that portion of the county which is underlain by Archean granites is notable for the small number of species present and its corresponding lack of floristic interest. Nearly as poor floristically as the Jack-pine barrens proper is the west central part of the county as exemplified by the region around Winchell Lake. Here the red rock differentiate of the Duluth gabbro is the underlying rock. It breaks up into large blocks which accumulate below the cliff faces and weather but slowly so that little soil is formed from this massive rock type. The cliffs are abundant and high, but extremely limited in number of species of vascular plants. This proved to be something of a disappointment to the writers because this is the highest part of the Lake Superior-Hudson Bay watershed and, if "nunataks" in the Fernaldian sense could have been expected, this is where they should have been. The plants present gave no assistance in justifying such a hypothesis here. Nor did the abundant evidence of heavy and recent glaciation hold out hope from the geological point of view.

b. MIXED CONIFER-HARDWOOD FOREST.—The mixed conifer-hardwood forest in its multifarious aspects covers the greater part of the remainder of Cook County. The underlying rocks in this region of richer vegetation are the various intrusives and flows of the Keweenawan series (often less acid than the Archean granites) and sedimentaries of the Animikie series, notably the Rove slates. The drift mantle is more varied, often more clayey and the exposed intrusives tend to weather more rapidly than do the rock surfaces of the Winchell Lake and Archean areas.

Tree species which are characteristic of the mixed conifer-hardwood forest are *Abies balsamea, Pinus Banksiana, Populus tremuloides, Betula papyrifera* (*sens. lat.*), *Picea glauca*, and occasionally, *Pinus Strobus* and *P. resinosa.* Different phases of this forest have different proportions of these tree species. Shrubs and small trees often present with these are *Acer spicatum, Amelanchier* spp., *Corylus cornuta, Lonicera canadensis, Prunus pensylvanica, Rubus idaeus* var. *strigosus, R. parviflorus* (*sens. lat.*), *Salix* spp., etc. Ground cover includes *Antennaria* spp., *Aralia nudicaulis, Aster ciliolatus, A. macrophyllus, Clintonia borealis, Cornus canadensis, Epilobium angustifolium, Habenaria obtusata, Lathyrus ochroleucus, Mertensia paniculata, Oryzopsis pungens, Poa palustris, Pteridium aquilinum* var. *latiusculum, Schizachne purpurascens, Solidago* spp., *Trientalis borealis,* etc., etc.

Occasional groves of *Pinus Strobus* occur here and there in the mixed forest, and in these groves occur as associates *Abies balsamea, Acer spicatum, Anemone quinquefolia, Aster macrophyllus, Betula cordifolia, Clintonia borealis, Cornus canadensis, Corylus cornuta, Lycopodium annotinum, L. obscurum* var. *dendroideum, Maianthemum canadense, Prunus pensylvanica, Pteridium aquilinum* var. *latiusculum, Pyrus americana,* and *Viola* *renifolia*. Similarly *Pinus resinosa* occasionally forms groves on lighter well-drained soils which are often of a morainic character.

There is also a Jack-pine phase of the mixed forest in which *Abies balsamea* is sometimes the understory, along with occasional individuals of *Picea mariana* and *Betula papyrifera*. Present with these are *Amelanchier humilis*, *Apocynum androsaemifolium*, *Aralia nudicaulis*, *Aster macrophyllus*, *Chimaphila umbellata* var. *cisatlantica*, *Clintonia borealis*, *Cornus canadensis*, *Corylus cornuta*, *Danthonia spicata* var. *pinetorum*, *Fragaria virginiana*, *Goodyera repens*, *Halenia deflexa*, *Linnaea borealis* var. *americana*, *Lonicera canadensis*, *Melampyrum lineare*, *Moneses uniflora*, *Pteridium aquilinum* var. *latiusculum*, *Pyrola secunda*, *Spiranthes gracilis*, *Streptopus roseus* var. *longipes*, *Vaccinium myrtilloides*, etc.

Thuja occidentalis and *Picea mariana* often predominate in less well drained places in the mixed hardwood forest. Associated with them are *Abies balsamea*, *Alnus rugosa* var. *americana*, *Aralia nudicaulis*, *Athyrium angustum* var. *rubellum*, *Betula cordifolia*, *Carex disperma*, *Clintonia borealis*, *Coptis groenlandica*, *Cornus canadensis*, *Dryopteris disjuncta*, *D. spinulosa*, *Gaultheria hispidula*, *Habenaria obtusata*, *Linnaea borealis* var. *americana*, *Lycopodium annotinum*, *Maianthemum canadense*, *Mitella nuda*, *Moneses uniflora*, *Osmunda Claytoniana*, *Oxalis montana*, *Pyrus americana*, *P. decora*, *Ribes* spp., *Rubus pubescens*, *Trientalis americana*, *Viola palustris*, etc.

Rarely, limited groves of *Fraxinus nigra* occur in protected moist depressions in the mixed forest and with it occur, as associates, *Ranunculus septentrionalis*, *Galium trifidum* and others.

The dry hilltops and exposed dry rock ledges and drier cut banks may or may not have tree cover, but are likely to have present such herbaceous species as *Arabis divaricarpa*, *Campanula rotundifolia*, *Carex xerantica*, *Chenopodium hybridum* var. *gigantospermum*, *Convolvulus spithamaeus*, *Corydalis sempervirens*, *Danthonia spicata* var. *pinetorum*, *Equisetum hiemale* var. *affine*, *Geranium Bicknellii*, *Heuchera Richardsonii*, *Lactuca ludoviciana*, *Oryzopsis pungens*, *Poa compressa*, *P. interior*, *Potentilla tridentata*, *Selaginella rupestris*, etc.

Highly localized open gravel pits have been created in the course of the limited road-building program of the county.

Here appear among other species *Aster macrophyllus, Bidens vulgata* var. *puberula, Carex Crawfordii, C. Houghtoniana, Gnaphalium Macounii, Juncus brevicaudatus, J. bufonius, J. tenuis* f. *Williamsii, Poa palustris, Typha latifolia*, etc., the species present depending on whether the gravel pits are dry or wet.

The weed flora is extensive especially along roadsides, although occasionally an introduced species will gain a foothold near one of the tourist lodges. The more certain snow cover in the winter, along with the cool summers, may well explain the success of many north European weeds in Cook County, while in contrast the same species do but poorly (except in gardens) farther south in the state. Very obvious examples of this are *Chrysanthemum Leucanthemum, Ranunculus acris* and *Polygonum Hydropiper*. Other weed species are *Silene Armeria, Carum Carvi*, and *Viola tricolor*.

The mixed forest is freely interspersed with streams, rivers, and occasional back waters and flood plains, lakes, swamps, and bogs. The swamp woods are often dense and in them predominate *Larix laricina, Picea mariana* and *Thuja occidentalis*, with a very limited undergrowth of *Gaultheria hispidula, Equisetum scirpoides, Carex* spp., *Oxalis montana*, etc. Or *Alnus rugosa* var. *americana* dominates in some swamps, having associated with it *Dryopteris cristata, Aster puniceus, Glyceria canadensis* and *G. striata*, etc. Along stream banks occur as associates the familiar woody species *Alnus rugosa* var. *americana, Myrica Gale, Cornus stolonifera*, species of *Salix*, and *Fraxinus nigra*, with an undergrowth of *Thalictrum dasycarpum, Juncus effusus* var. *Pylaei* and *Scirpus pedicellatus*.

In the sphagnum bogs there is often an occasional *Larix laricina*, along with *Carex canescens* var. *subloliacea, C. cephalantha, C. Houghtoniana, C. paupercula* var. *pallens, C. vaginata, Chamaedaphne calyculata, Dryopteris spinulosa* var. *americana, Glyceria striata* var. *stricta, Ledum groenlandicum, Monotropa uniflora, Osmunda cinnamomea, Potentilla palustris, Utricularia intermedia, U. minor*, etc. Along lake shores there frequently occur *Scutellaria epilobiifolia, Megalodonta Beckii, Galium trifidum, Glyceria borealis, Spiraea alba, Lysimachia terrestris*, etc.

In the back waters of streams or in shallow slow streams are to be found *Calla palustris, Callitriche palustris, Carex rostrata* var. *utriculata*, *Eleocharis palustris* var. *major*, *Glyceria Fernaldii*, *Hippuris vulgaris* f. *fluviatilis*, *Isoëtes muricata*, *Potamogeton Berchtoldi*, *Sagittaria latifolia* f. *gracilis*, *Scirpus pedicellatus*, etc. Smith and Moyle (1944) characterize the water of the streams of the North Shore as comparatively soft, the plants being therefore members of the soft water flora or else widely tolerant and ubiquitous. They point out that hard-water species such as water cress are absent.

In the lakes there are *Elodea canadensis*, *Isoëtes macrospora*, *Lobelia Dortmanna*, *Myriophyllum alterniflorum* var. *americanum*, *Najas flexilis*, *Nuphar rubrodiscum*, *Potamogeton epihydrus* var. *Nuttallii*, *P. gramineus*, *P. praelongus*, *P. Spirillus*, *Sagittaria cuneata*, *Sparganium angustifolium*, and rarely, *Subularia aquatica*.

c. The sugar-bush.—The existence of localized sugar-bush along the north shore of Lake Superior has been an object of special comment at least since Dr. John Bigsby (1850, vol. 2, pp. 202–3) in 1823 observed "a ridge of sugar maple trees many miles long" which extended westward from Michipicoten Bay "with breaks" to St. Mary's River at a "distance of ten, fifteen, twenty miles from the lake." He goes on to say "There is another, which stretches from the Perdrix [Pigeon] Falls, near the Grand Portage, to the Fond du Lac. Those extensive groves of sugar-maple are highly prized by the Indians." No doubt a search of the early literature, manuscript diaries, etc. would reveal mention by those who came before him of the use of the products of the sugar maple by the Indians of the region. It would be surprising if so highly esteemed a product as maple sugar had not entered into the ventures of the old fur traders.

Today there are still groves of sugar maple along this shoulder of the upland in Cook County. In addition to *Acer saccharum*, there are present as highly characteristic associates *Maianthemum canadense* var. *interius* (replaced in the surrounding country by *M. canadense*, *sens. str.*), *Smilacina racemosa*, *Polygonatum biflorum*, *Arisaema atrorubens*, *Osmorhiza Claytoni*, *Betula lutea*, etc.

The survival of so familiar an association as the sugar-bush well north of its optimum region of development in the state may be attributed to the probability that there is a longer frost-free period at the edge of the upland, where air drainage is more active than elsewhere in the county. *Acer saccharum* is notably susceptible to frost, especially in the spring, and would presumably not thrive if late spring frosts were at all frequent along the edge of the upland. In a preceding section on Climate it has been pointed out that, if these relic stands represent a former northeastward extension of the "Big Woods," the climate in the county during the thermal maximum can be roughly characterized. Judging by the present climate in the Big Woods region of south central Minnesota, there would have been a growing season some 20 days longer, with the last spring frosts occurring earlier, but with little change in the date of the less critical fall frosts; and mid-summer temperatures (July) averaging perhaps 10° F. higher than they now do. Whether the soils of the sugar-bush in Cook County reflect the climatic history still remains to be determined.

6. The Localized Habitats and Their Plants

There is a poorly defined line between the groups of plants mentioned in the preceding section and in the present. Thus the sugar-bush, the roadside weeds, and the plants growing in the recent gravel pits might appropriately have been considered here.

It is the puzzling phytogeographic picture presented by the rarer plants of the localized habitats mentioned below which tends to hold them together. Some simple system of assigning these species, many disjunct in their distribution, to particular phytogeographic categories was needed. We recognize the problems which, as Raup (1947, pp. 63 and 64) points out, make difficult the assignment of a given species to a particular phytogeographical subdivision. This is aggravated in the case of a species whose distribution may be disjunct at one or another extremity of its total range. However, on a purely pragmatic basis it is more useful for the present purposes to generalize the ranges rather than to particularize them. If the latter procedure is carried to its ultimate extreme the distribution of each species becomes a special phytogeographical case.

The general system of classification used by Scoggan (1950) has been somewhat modified and is our basis for characterizing distributional patterns. A series of roughly latitudinal major headings are established; under each is a series of subheadings which is roughly longitudinal. Sharp classification according to such a scheme is not possible and a considerable degree of arbitrariness results. Even so, difficulty arises with North American species. When a species extends outside of North America only whole continents or subcontinents are considered. And when the limits of any one continent are transgressed the vexed question of whether a species should be described as *alpine* or *arctic* is further aggravated, simple though this problem seemed to Agassiz (1850).

The following terms for distributional categories are recognized:—

The roughly latitudinal categories—

Arctic—extending *north* of tree line.

Boreal—extending northward *to* the northern limit of northern coniferous forest.

Temperate—extending northward to the southern limit of northern coniferous forest.

Southern—extending to the southern limit of the hardwood forest.

Hyphenization of pairs of these terms indicates that the species transgresses the boundaries indicated. The known distributions of species justify this procedure, as do also the broad ecotones.

The roughly longitudinal subheadings—

Circumpolar—essentially continuous distribution around the world.

Amer-asian—general American distribution plus Asian stations.

Amphiatlantic—essentially eastern American distribution with transatlantic stations in addition.

American—more or less generally distributed in North America.

Eastern American—more or less generally distributed east of 100° W. long.

Mid American—more or less mid-continental.

West American—more or less reaching an eastern limit at 90° W. long.

In addition to the above we use the self-explanatory terms, Great Lakes endemic, and Cook County endemic.

The habitats occupied by the rarer plants falling in this section are:—*a.* the cold, wet rocks and ledges immediately along the shore of Lake Superior; *b.* the gravel, shingle, or cobble beaches along the shore of Lake Superior; *c.* the moist, shady cliffs and cool canyon walls, both along the Border Lakes and by Lake Superior; *d.* the dry, sun-baked south-facing cliffs and dry cliff-tops; *e.* the portage trails, stream banks, open glades and moist roadside ditches; *f.* the sub-aquatic and aquatic habitats.

a. THE COLD, WET ROCKS AND LEDGES ALONG THE LAKE SUPERIOR SHORE (Plate 1191)—The plants growing on the bare rock of the smaller points extending out into Lake Superior and on the nearby ledges which often are wave-swept are notably under the immediate influence of the low temperature of the lake water. Often spring- or seepage-fed pools or pools replenished during lake storms are abundant on the points. The individual plants found on the points may be rooted simply in cracks in the rocks as is so dramatically the case with *Sagina nodosa;* or they may occur, a few together, sharing a clump of moss at the side of a rock pool or a limited patch of raw gravel in a rock crevice. At the upper limit of the zone these plants are present in somewhat larger numbers of individuals in the sphagnous cushions about the bases of scattered shrubs, such as *Potentilla fruticosa, Physocarpus opulifolius, Kalmia polifolia, Ledum groenlandicum, Chamaedaphne calyculata, Vaccinium uliginosum,* and *Salix* spp.

Among the species found on these points and ledges are:—the widespread boreal or arctic circumpolar, *Selaginella Selaginoides, Deschampsia flexuosa, Tofieldia pusilla, Allium Schoenoprasum* var. *sibiricum, Polygonum viviparum, Empetrum nigrum, Vaccinium uliginosum,* and *Pinguicula vulgaris;* the arctic-boreal amphiatlantic *Equisetum scirpoides;* the boreal amphiatlantic *Sagina nodosa;* the arctic-boreal or boreal American, *Parnassia palustris* var. *neogaea, Primula mistassinica, Geocaulon lividum;* the boreal east American *Empetrum atropurpureum;* the boreal mid-American *Euphrasia hudsoniana;* and the Great Lakes endemic *Primula intercedens.* In general these are calcicolous or indifferent and occur in the Pigeon Point, Grand Portage, Grand Marais areas where the shore rocks are slates or basic phases of the diabase trap. Very few of these species occur away from the shore, two exceptions being *Allium Schoenoprasum* var. *sibiricum* which is found on a cliff at North Fowl Lake in the Rove slate region, and *Parnassia palustris* var. *neogaea* in a moist, marly roadside ditch near Schroeder. Nor is the whole group of species mentioned above found at any one locality. There is considerable randomness of occurrence.

b. THE GRAVEL, SHINGLE AND COBBLE BEACHES ALONG THE SHORE OF LAKE SUPERIOR—The contemporary beaches of Lake Superior in Cook County are typically composed of coarse materials and are rather sparsely vegetated except at the forested upper margins well back from the influence of storm waves. On these beaches may occur the temperate eastern American *Agropyron repens* f. *trichorrhachis* and *A. repens* var. *subulatum* f. *Vaillantianum;* and the boreal-temperate circumpolar (*sens. lat.*) *Lathyrus japonicus* var. *glaber*.

Notably absent from the beaches visited in Cook County is *Elymus arenarius* which occurs in quantity on the *sand* beaches farther east along the north shore of Lake Superior.

c. The moist, shady cliffs and cool canyon walls (Plate 1190)—Most productive in the search of these localized habitats in Cook County for rarities are the moist, shady faces and upper talus margins of the north-facing cliffs of the Rove slate area. These cliffs face on the elongated, deep lakes near the border and also on some of the bays set off by the larger points of Lake Superior (notably Pigeon Point). Also the shady and moist canyons cut by the streams dropping off of the tableland prove to be favorable ecological niches for the growth of this group of rarities. Common to these habitats are:—the presence of finely comminuted rock forming a constantly replenished and fresh soil at the upper margin of the talus slopes and on the niches and ledges of the cliff faces; the constant supply of moisture; the neutral to mildly basic country rock; the absence of forest tree root competition and of heavy tree-shade and of low pH of forest duff. All these factors seem peculiarly favorable to the presence of a striking number of rarities and even to the development of a small group of endemics.

As in the case of the rarities on the shore rocks, those of the moist cliffs and canyons are often almost random in their occurrence. Sometimes, as with *Saxifraga cernua* var. *latibracteata*, the species is known from Cook County (and Minnesota) from but a few square feet at the top of a single talus slope; sometimes, as in the case of the local endemic *Oxytropis ixodes*, it luxuriates over several acres of cliff and talus (Plate 1190-B) but is found on only one lake (in this case its var. *ecaudata* occurs similarly on the next lake north in the chain); or sometimes as in the cases of *Calamagrostis purpurascens* or the endemic *Poa scopulorum* (of the *Oreinos* group) or *Arnica chionopappa* (Plate 1190-C), it will occur on several cliffs. Most of the species are notorious calcicoles, and the remainder indifferent.